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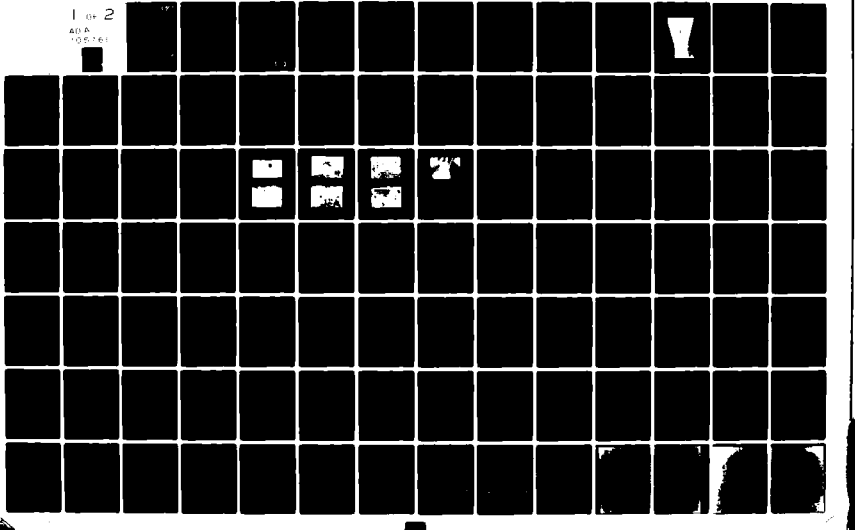
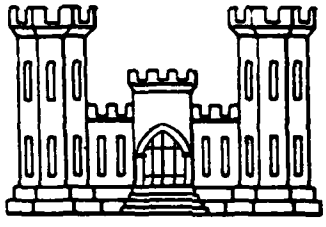


PASSAIC RIVER BASIN
LOWER HUDSON RIVER AREA

HILLBURN RESERVOIR DAM LEVEL II

ROCKLAND COUNTY, NEW YORK
INVENTORY NO. N.Y. 974

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



NEW YORK DISTRICT CORPS OF ENGINEERS

JUNE 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety
National Dam Safety Program
Visual Inspection
Hydrology, Structural Stability
Hillburn Reservoir Dam
Rockland County
Passaic River Basin

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

Examination of available documents and a visual inspection of the dam and appurtenant structures did not reveal conditions which constitute an immediate hazard to human life or property.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Using the Corps of Engineers' screening criteria, it has been determined that the dam would be overtopped for all storms exceeding approximately 2.5 percent of the Probable Maximum Flood (PMF). The spillway is, therefore, adjudged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate spillway" is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that, based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity, so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream.

On the basis of stability analyses of the masonry/concrete gravity portion of the dam performed for this investigation, the factors of safety against overturning are inadequate and the locations of the resultants fall outside of the middle 1/3. The factor of safety of the dam against sliding was determined to be less than the recommended guidelines for all loading conditions.

The three piping holes at the toe of the dam should be investigated to find the cause and effect on the structural stability of the dam. An in-depth engineering study should be conducted to determine the actual stability conditions of the dam. The results of these investigations and analyses will determine the appropriate remedial measures which will be required to achieve a spillway capacity adequate to discharge the outflow from at least the 1/2 PMF. In the interim, a detailed emergency action plan must be developed and implemented during periods of unusually heavy precipitation. Also, around-the-clock surveillance must be provided during these periods.

It is therefore recommended that, within three months of notification of the owner, detailed hydrologic and hydraulic investigations of the structure should be undertaken to more accurately determine the site-specific characteristics of the watershed and their effects upon the overtopping potential of the dam.

Formal inspection and maintenance procedures should be developed with records maintained for future reference of inspection and maintenance completed.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HILLBURN RESERVOIR DAM
I.D. No. NY 974
DEC DAM No. 196A-934 PASSAIC RIVER BASIN
ROCKLAND COUNTY, NEW YORK

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Hillburn Reservoir Dam (I.D. No. NY 974)
State:	New York
County:	Rockland
Stream:	Unnamed Tributary of Ramapo River
Dates of Inspection:	9 January 1981 10 March 1981

ASSESSMENT

Examination of available documents and a visual inspection of the dam and appurtenant structures did not reveal conditions which constitute an immediate hazard to human life or property.

Using the Corps of Engineers' screening criteria, it has been determined that the dam would be overtopped for all storms exceeding approximately 2.5 percent of the Probable Maximum Flood (PMF). The spillway is, therefore, adjudged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The classification of "unsafe" applied to a dam because of a "seriously inadequate spillway" is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that, based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity, so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream.

On the basis of stability analyses of the masonry/concrete gravity portion of the dam performed for this investigation, the factors of safety against overturning are inadequate and the locations of the resultants fall outside of the middle 1/3. The factor of safety of the dam against sliding was determined to be less than the recommended guidelines for all loading conditions.

The three piping holes at the toe of the dam should be investigated to find the cause and effect on the structural stability of the dam. An in-depth engineering study should

be conducted to determine the actual stability conditions of the dam. The results of these investigations and analyses will determine the appropriate remedial measures which will be required to achieve a spillway capacity adequate to discharge the outflow from at least the 1/2 PMF. In the interim, a detailed emergency action plan must be developed and implemented during periods of unusually heavy precipitation. Also, around-the-clock surveillance must be provided during these periods.

It is therefore recommended that, within three months of notification of the owner, detailed hydrologic and hydraulic investigations of the structure should be undertaken to more accurately determine the site-specific characteristics of the watershed and their effects upon the overtopping potential of the dam.

Formal inspection and maintenance procedures should be developed with records maintained for future reference of inspection and maintenance completed.

The following remedial measures must be completed within one year:

1. The seeps in the downstream face of the dam should be monitored to determine if seepage quantities are increasing.

2. The blow-off pipes should be made operable.

3. The mortar in the masonry joints in the downstream face should be repaired.

4. The valve house should be repaired.

5. The downstream channel below the spillway should be cleared of all obstructions to flow.

6. The three trees should be removed from the downstream face of the dam.

7. The concrete wing wall at the right abutment should be repaired.

8. The spalling on the upstream face of the concrete cap should be repaired.

9. All trees and brush at the downstream toe of the dam should be cut at ground level. The root systems of all trees with a trunk diameter greater than 3 inches should be removed. All resultant areas of erosion and cavities should be filled, compacted, and seeded.

SUBMITTED: _____

Granville Kestey, Jr., P.E.
Vice President
MICHAEL BAKER, JR. of New York, INC.

APPROVED: _____

Colonel W.M. Smith, Jr.
New York District Engineer

DATE: 30 JUN 1981

Overall View of Dam
Hillburn Reservoir Dam
I.D. No. NY 974
10 March 1981

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
HILLBURN RESERVOIR DAM
I.D. No. NY 974
DEC No. 196-934
PASSAIC RIVER BASIN
ROCKLAND COUNTY, NEW YORK

SECTION 1: PROJECT INFORMATION

1.1 GENERAL

a. Authority - The Phase I Inspection reported herein was authorized by the Department of the Army, New York District, Corps of Engineers, to fulfill the requirements of the National Dam Inspection Act, Public Law 92-367.

b. Purpose of Inspection - This inspection was conducted to evaluate the existing conditions of the dam, to identify deficiencies and hazardous conditions, to determine if these deficiencies constitute hazards to life and property, and to recommend remedial measures where required.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam - Hillburn Reservoir Dam is a concrete capped masonry structure with a height of 26.0 feet and a length of 476 feet. The dam is formed by two sections of nearly equal length. The right section is situated normal to the stream valley. The left section is situated at an angle of 115°± from the other, nearly parallel to the stream valley. The crest of the left section is approximately 0.5 to 1.0 foot higher than the crest of the right section.

There is an earth embankment along the downstream face of the left section of the dam. This embankment extends up to the crest of the dam and has 1V:3H (Vertical to Horizontal) side slopes and a maximum height of approximately 6 feet.

The spillway consists of three adjacent, shallow (0.7 foot) notches in the crest of the right section of the dam, each 8 feet wide. The notches will accept flashboards, although the owner's representative reported that none have been used

for several years. Discharges through the notches cascade down the masonry face of the dam to a boulder-lined discharge area.

A valve house is located on the upstream side of the dam just to the left of the spillway. A 12-inch cast iron water supply pipe leads from the valve house to a chlorinator building situated approximately 100 feet downstream of the dam. Two additional 8-inch cast iron pipes lead from the valve house to just below the dam and serve as outlets. There are valves for the 8-inch pipes at the valve house and at the outlet end. None of the valves have been operated for 7-9 years.

b. Location - Hillburn Reservoir Dam, located on an unnamed tributary of the Ramapo River, is 0.8 mile west of Hillburn, New York. The reservoir and dam are in Rockland County, New York. The coordinates of the dam are N 41° 07.5' and W 74° 11.0'. The dam can be found on the Sloatsburg and Ramsey, New York, USGS 7.5 minute topographic quadrangles.

c. Size Classification - Hillburn Reservoir Dam is 26.0 feet high, based on the maximum section in the stability calculations, and the reservoir storage capacity at the crest of the dam (elevation 594.3 feet M.S.L.) is 28 acre-feet. Therefore, the dam is in the "small" size category as defined by the Recommended Guidelines for Safety Inspection of Dams (Reference 15, Appendix E).

d. Hazard Classification - Nine houses are located downstream from the dam; one at 700 feet, one at 1400 feet, and seven at 2500 feet. There is possible loss of life in all of the homes in the event of dam failure. Hillburn Reservoir Dam is therefore considered in the "high" hazard category as defined by the Recommended Guidelines for Safety Inspection of Dams.

e. Ownership - The dam and reservoir are owned and operated by the Village of Hillburn, 31 Mountain Avenue, Hillburn, New York 10931. The contact person is Mr. Allan Garfinkel, Village Engineer (Telephone 914-357-0999).

f. Purpose of the Dam - Hillburn Reservoir was originally used as a water supply for the Village of Hillburn, New York, but was abandoned two years ago because the flow quantity and quality were unreliable.

g. Design and Construction History - Hillburn Reservoir Dam was constructed about 1906. The original designer and contractor are unknown. In 1931 the dam was raised 1 foot by the addition of a concrete cap. The design was by Bogart and Pohl Engineers of New York City. The contractor is unknown.

h. Normal Operating Procedures - The reservoir level is normally maintained at the spillway crest. According to the owner, the dam is visited daily. All valves on the blow-off pipes and water supply line are closed and have not been operated for 7-9 years.

1.3 PERTINENT DATA

a. Drainage Area (Acres) -	340
b. Discharge at Dam (c.f.s.)	
Spillway Capacity (at Pool Elev. 595.0 ft. M.S.L.)	37.0
Reservoir Drain at Normal Pool Level	12.2
c. Elevation (Feet Above M.S.L.)*	
Minimum Top of Dam	595.0
Normal Pool (Spillway Crest)	594.3
Streambed at Toe of Dam	572.7
d. Reservoir Surface Area (Acres) -	
Top of Dam (Elev. 595.0 ft. M.S.L.)	3.2
Spillway Crest (Elev. 594.3 ft. M.S.L.)	2.8
e. Reservoir Storage Capacity (Acre-Feet) -	
Top of Dam (Elev. 595.0 ft. M.S.L.)	28.0
Spillway Crest (Elev. 594.3 ft. M.S.L.)	26.0
f. Dam -	
Type: Masonry gravity with concrete cap.	
Length (Feet)	476.0
Height (Feet)	22.3
Crest Width (Feet)	4.0
Side Slopes - Upstream	Vertical
Downstream	3V:1H

*All elevations are referenced to the crest of the dam, elev. 595.0 ft. M.S.L., estimated from the 7.5 minute USGS topographic quadrangle, Sloatsburg, New York.

g. Spillway -

Type: 3-section, concrete, broad-crested weir	
Total Crest Length Perpendicular to Flow (Feet)	24.0
Crest Width Parallel to Flow (Feet)	4.0
Crest Elevation (Feet M.S.L.)	594.3

h. Reservoir Drain -

Type: Two 8-inch cast iron pipes to the stream 50 feet downstream from the toe of the dam.
Control: There are two manually controlled gate valves in the gatehouse on the crest of the dam and two gate valves on the downstream end of the two 8-inch pipes.

SECTION 2: ENGINEERING DATA

2.1 GEOLOGY

The Hillburn Reservoir Dam is located in the southern end of the "New England Uplands" physiographic province of New York State. This province is geologically complex and composed of characteristically diverse metamorphic and igneous rock. Bedrock occurring in the immediate vicinity of the dam, as indicated on the Geologic Map of New York (J. G. Broughton and others, 1970), consists of Precambrian (greater than 600 million years ago) amphibolite and hornblende granitic gneiss. A northeast-southeast trending normal fault plane, as shown on the Geologic Map of New York, lies approximately two miles east of the dam and represents the only major fault within this area. This entire area has been repeatedly glaciated by the major ice advances which occurred during the Pleistocene Epoch. The most recent ice advance ended approximately 11,000 years ago.

2.2 SUBSURFACE INVESTIGATIONS

No records of any subsurface investigations performed for this structure could be located. The available plans and an application for permission to rehabilitate the dam in 1931 indicate that the structure is founded on sand, clay and boulders. A visual observation indicates that the valley floor appears to be covered by glacial debris in the form of silty soil and sub-rounded boulders.

According to the available soils report for Rockland County, prepared by the USDA Soil Conservation Service, most of the local foundation materials consist of "Charlton extremely stony loam". These soils are relatively deep (4 to 10 feet), moderately coarse textured, stony soils formed in acid glacial till. The foundation materials in the vicinity of the northeastern border of the structure consist of "Hollis fine sandy loam". The Hollis soils are shallow (10 to 20 inches), moderately coarse textured soils formed also in acid glacial till.

2.3 DAM AND APPURTENANT STRUCTURES

The dam was originally built around 1906 as a water supply for the community of Hillburn, situated less than a mile to the east of the facility. The dam is a concrete capped masonry structure formed by two sections of nearly equal length. The right section is situated

normal to the stream valley. The left section is situated at an angle of 115°± from the other, nearly parallel to the stream valley. There is an earth embankment along the downstream face of the left section of the dam. This embankment extends up to the crest of the dam and has 1V:3H side slopes and a maximum height of approximately 6 feet. The spillway consists of three adjacent, shallow (0.7 foot) notches, each 8 feet wide, in the right wall. Discharges through the notches cascade down the masonry face of the dam to a boulder-lined discharge area. The original spillway openings are believed to have been approximately 20 feet deep (refer to Plate 2, Appendix F). It is unknown if the masonry walls are founded on bedrock or the local loamy soils.

A valve house is located on the upstream side of the dam just to the left of the spillway. A 12-inch cast iron water supply pipe leads from the valve house to a chlorinator building situated approximately 100 feet downstream of the dam. Two additional 8-inch cast iron pipes lead from the valve house to just below the dam and serve as outlets. There are valves for the 8-inch pipes at the valve house and at the outlets. None of the valves have been operated for 7-9 years.

2.4 CONSTRUCTION RECORDS

Construction records are not available. Records relating to 1931 rehabilitation measures (raising the dam 1 foot with a concrete cap) are included in Appendices F and G.

2.5 OPERATION RECORDS

No operation records were found during this investigation.

2.6 EVALUATION OF DATA

The background information collected during this investigation was obtained primarily from files of the New York State Department of Environmental Conservation. Supplementary information was acquired through conversations with Mr. Allan Garfinkel, Hillburn Village Engineer. The available data are considered adequate and reliable for Phase I Inspection purposes.

SECTION 3: VISUAL INSPECTION

3.1 FINDINGS

a. General - The inspection was performed on 9 January 1981. The weather was cloudy and the temperature was 10°-20°F. with 2-4 inches of snow on the dam; 2 inches of snow on the crest of the dam; and 4 inches of snow on the ground. The water surface was 6.1 feet below the spillway crest. Deficiencies found during the inspection will require remedial treatment. A Field Sketch of conditions found during the inspection is included in Appendix F. The complete Visual Inspection Checklist is presented as Appendix B. Because there was a snow cover on the dam during the initial inspection, a follow-up inspection was carried out on 11 March 1981.

b. Spillway - The spillway is located approximately 100 feet from the right abutment. The spillway consists of 3 separate 8 foot notches, each 0.7 foot deep, in the concrete cap on the dam. Each spillway section has notches for flashboards to be installed, but the owner's representative reported that flashboards have not been used for some time. The spillway was in good condition at the time of inspection. The spillway discharges over the downstream face of the dam and into the discharge channel.

c. Dam - Hillburn Reservoir Dam is a masonry structure formed by two walls, 476 feet in total length and 22.3 feet high. The entire masonry structure has a concrete cap that is in good condition, with a small amount of spalling present on the upstream face of the cap.

The mortar in masonry joints is generally deteriorated with many cracks and gaps, especially from the spillway to the right abutment. Two seeps (0.5 gpm) are located on the downstream face of the dam beneath the spillway. There are also several smaller seeps located beneath the spillway. What appeared to be a piping hole was observed at the downstream toe of the dam at Station 0+55. After clearing material away from the hole and allowing approximately 45 minutes to elapse to allow for the removal of material pushed into the hole, a steady flow rate of approximately 2-3 gpm was observed. At the surface, a well-defined hole 1

inch in diameter was visible. This hole tapered down to 0.5 inch in diameter at a depth of 4-5 inches. Fine material (silt and/or sandy particles) was being carried out of the hole. At no time was the flow colored or significantly turbid. The exact depth of the hole could not be determined. There are three trees, 2-5 inches in diameter, growing in the downstream masonry face of the dam between the spillway and right abutment. There are many trees, ranging from 4-24 inches in diameter, growing along the downstream toe of the dam. The concrete wing wall at the right abutment has collapsed.

d. 10 March 1981 Inspection - This inspection was conducted with representatives present from the New York District, Corps of Engineers, and the New York Department of Environmental Conservation.

The reservoir was full with approximately 2 inches of flow over the spillway crest during the inspection. Seepage was observed under a majority of the concrete cap on the dam. Two additional piping holes (each 1 inch in diameter) were observed at the downstream toe of the left section of the dam. Flow from the holes was about 2-3 gpm and was clear. There is an abandoned water line in the vicinity of these holes, and it is suspected that a leak in this line is the likely source of the flow. This is not believed to be a serious problem at this time because the height of the embankment at the location of these holes is only a few feet, and because the source of the flow is probably the abandoned water line.

e. Outlet Works - The valve house is located on the upstream face of the dam at the crest. Three pipes exit the valve house. One 12-inch pipe is a water supply line that extends to the chlorinator building 100 feet from the toe of the dam. Two 8-inch cast iron blow-off pipes exit the valve house and discharge into the downstream channel. The valves in the valve house and the valves on the downstream end of the blow-off pipes have not been operated for the last 7-9 years. In the valve house, the mortar in the masonry joints of the foundation is deteriorating. The majority of the boards from the wood plank floor in the valve house are missing.

f. Downstream Channel - The downstream channel below the spillway is full of large boulders and debris.

The downstream channel below the blow-off pipes has a moderate to steep slope, full of large boulders and debris.

Nine houses are located downstream from the dam; one at 700 feet, one at 1400 feet, and seven at 2500 feet.

g. Reservoir - The slopes of the reservoir are moderate to steep, rock covered and wooded. There were no signs of instability and sedimentation was not reported to be a significant problem.

3.2 EVALUATION

The visual inspection revealed several deficiencies in this dam. The following items were noted:

1. Three small piping holes, flowing at 2-3 gpm, were observed at the toe of the dam.

2. Two seeps are located on the downstream face of the dam beneath the spillway. Also, there are several smaller seeps located beneath the spillway.

3. The mortar in the masonry joints is generally deteriorated with many cracks and gaps, especially from the spillway to the right abutment.

4. The valves for the blow-off pipes have not been operated for 7 to 9 years.

5. The downstream channel below the spillway is full of large boulders and debris.

6. There are three trees growing in the masonry face of the dam, and many trees growing at the toe of the dam.

7. The masonry joints in the foundation, and the entire valve house is in a deteriorated condition.

8. The concrete wing wall at the right abutment has collapsed.

9. There is some spalling present on the upstream face of the concrete cap.

SECTION 4: OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES

There are no formal written instructions for operating the reservoir. The normal water surface elevation is at the spillway crest, but because of the water shortage in the area, the water surface at the time of inspection was 6.1 feet below the spillway crest. Water can be released to the downstream area by the two 8-inch cast iron blow-off pipes. The blow-off pipes have valves in the gate house and also on the downstream end.

4.2 MAINTENANCE OF THE DAM

Maintenance of the dam is the responsibility of the Village of Hillburn. The maintenance of the dam is not considered adequate, as evidenced by the general deterioration of the dam. The valves on the blow-off pipes have not been operated for 7-9 years. The valve house is in poor condition, the mortar in the masonry joints is deteriorating, and the majority of the boards from the wood plank floor in the valve house are missing. Mr. Winter, Superintendent of Public Works, visits the dam daily, while inspecting a water storage tank at the dam site.

4.3 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

At the time of the inspection, there was no warning system or emergency action plan in operation.

4.4 EVALUATION

The dam and appurtenant facilities have not been maintained in a satisfactory condition. A checklist should be compiled by the owner's representative to document the findings made during the periodic inspections and the maintenance items completed. A warning system and emergency action plan should be developed and put into operation.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 DRAINAGE AREA CHARACTERISTICS

Delineation of the watershed of Hillburn Reservoir Dam was made using the USGS 7.5 minute topographic quadrangles for Sloatsburg and Ramsey, New York. The drainage basin has moderate to steep slopes which are well covered by forests and ground vegetation. Some storage exists in the form of a large swampy area located upstream of Hillburn Reservoir. There has been no significant development within the 340 acre drainage area.

5.2 ANALYSIS CRITERIA

An hydrologic analysis of the watershed and an hydraulic analysis of dam was conducted using the U.S. Army Corps of Engineers' Flood Hydrograph Package HEC-1 DB computer program (Reference 12, Appendix E). The unit hydrograph was defined using the Snyder Unit Hydrograph Method. Estimates of the Snyder's unit hydrograph coefficients were based upon average coefficients from the Hydrologic Flood Routing Model for the Lower Hudson River Basin (Reference 16, Appendix E). Precipitation data was taken from Hydrometeorological Report No. 33 (Reference 8, Appendix E). Rainfall losses were estimated at an initial loss of 1.0 inch and a constant loss rate of 0.1 inch per hour thereafter. The hydraulic capacity of the dam, reservoir, and spillway was determined by incorporating the Modified Puls Routing Method. All flood routings were begun with the reservoir at normal pool level. Outlet discharge capacity was computed by hand. The Probable Maximum Flood (PMF) and 1/2 Probable Maximum Flood (1/2 PMF) were developed and routed through the reservoir.

5.3 SPILLWAY CAPACITY

The spillway capacity at the minimum top of dam is 37 cubic feet per second (c.f.s.). There is no auxiliary or emergency spillway at Hillburn Dam.

5.4 RESERVOIR CAPACITY

The storage capacity of Hillburn Reservoir at normal pool is 26 acre-feet. The storage capacity of the reservoir at the minimum top of dam is 28 acre-feet. Therefore, flood control storage of the reservoir between the spillway crest and top of dam is 2 acre-feet. This volume represents a total of 0.70 inch of runoff from the watershed.

5.5 FLOODS OF RECORD

No information concerning the effects of significant floods on the dam is available.

5.6 OVERTOPPING POTENTIAL

The maximum capacity of the spillway is 37 c.f.s. before overtopping would occur. The peak outflows of the PMF and 1/2 PMF are 1664 c.f.s. and 831 c.f.s., respectively. Therefore, the spillway is capable of passing 2.5 percent of the PMF before overtopping would occur.

5.7 RESERVOIR EMPTYING POTENTIAL

The reservoir can be drawn down by means of two 8-inch cast iron pipes controlled by gate valves on the upstream and downstream ends. Neglecting inflow, the reservoir can be drawn down from normal pool in approximately 33 hours. This is equivalent to an approximate drawdown rate of 0.65 feet per hour, based on the hydraulic height measured from normal pool divided by the time to dewater the reservoir.

5.8 EVALUATION

Hillburn Reservoir Dam is a "small" size - "high" hazard dam requiring the spillway to pass a flood in the range of the 1/2 PMF to PMF. The PMF and 1/2 PMF were routed through the watershed and dam. It was determined that the spillway is capable of passing 2.5 percent of the PMF before overtopping the dam. The spillway is, therefore, judged to be "seriously inadequate."

Conclusions pertain to present conditions and the effect of future development on the hydrology has not been considered.

SECTION 6: STRUCTURAL STABILITY

6.1 EVALUATION OF EMBANKMENT STABILITY

a. Visual Observations - A number of significant deficiencies related to the stability of the structure were noted during the visual inspection. These include:

1. Much of the mortar between individual stones of the masonry walls is badly deteriorated, cracked, or completely weathered away (particularly right of the spillway). Also, several stones are missing.

2. Two leaks (up to 0.5 gpm each) and numerous smaller leaks are occurring through the bottom courses of masonry wall immediately below the spillway (the level at which the leaks occur may represent the level of the original spillway crest).

3. What appeared to be a piping hole was observed at the downstream toe of the dam at Station 0+55. A steady flow of 2-3 gpm was observed exiting the hole. At the surface, a well-drained hole 1 inch in diameter was visible which tapered to 0.5 inch in diameter at a depth of 4-5 inches. Fine material was being carried out of the hole but at no time was the flow colored or significantly turbid.

4. Three trees, ranging from 2-5 inches in diameter, are growing on the downstream face of the masonry wall between the spillway and the right abutment.

5. The valves for the 8 inch outlets ("blow-off" pipes) have not been operated for 7 to 9 years.

b. Design and Construction Data - No design information was available regarding the stability of the structure.

c. Operating Records - Operating records are not available.

d. Post Construction Changes - A 12-inch concrete cap was placed on the masonry walls during 1931. The

facility was generally abandoned for water supply purposes approximately 2 years ago because the quantity and quality of water available was unreliable.

6.2 STRUCTURAL STABILITY ANALYSIS

The results of any previous stability analysis were unavailable for reference during this evaluation. A structural stability analysis has been conducted for the maximum masonry section of the dam situated near the spillway. The cases analyzed and respective results are as follows:

Case	Description of Loading Conditions
1	Normal operating conditions with reservoir at the spillway crest, full uplift and no tailwater.
2	Same as Case 1 with the addition of ice loading of 5000 pounds per lineal foot.
3	Reservoir level during 1/2 PMF (elev. 596.2 T.B.M.), with full uplift, and a tailwater of 4.5 feet.
4	Reservoir level during the PMF (elev. 596.74 T.B.M.), with full uplift, and a tailwater of 6.0 feet.

	Factor of Safety		Location of Resultant
Case	Overturning	Sliding	from Toe (ft.)
1	1.04	3.7	0.57
2	0.72	2.9	-6.0
3	0.85	3.1	-3.1
4	0.83	3.1	-4.0

Notes: Location of middle 1/3 is 5.0 to 10.0 feet from the downstream toe.

A negative sign above indicates that the resultant falls downstream of the toe.

A value of .19 KSF was used as a conservative approximation of the shear strength of sandy silt.

Hillburn Reservoir Dam is situated in Seismic Zone 1. Seismic loading evaluations are not necessary for dams in this seismic zone.

In all cases analyzed, the factors of safety against overturning are low and the locations of the resultants fall outside of the middle 1/3. Therefore, the dam is considered unsafe against overturning. However, the structure has withstood normal loading conditions in the past without apparent damage, and the analyses may not indicate the true field conditions or proper loading conditions. Therefore, it is recommended that an in-depth engineering study of the structure be conducted to determine actual stability conditions prior to initiating any remedial measures.

SECTION 7: ASSESSMENT/RECOMMENDATIONS

7.1 ASSESSMENT

a. Safety - Examination of available documents and visual inspections of Hillburn Reservoir Dam did not reveal any conditions which are considered to be hazardous.

Using the Corps of Engineers' screening criteria for review of spillway adequacy, it has been determined that the dam would be overtopped for all storms exceeding approximately 2.5 percent of the PMF. The overtopping of the dam could result in dam failure, increasing the hazard to loss of life downstream. The spillway is, therefore, adjudged as "seriously inadequate" and the dam is assessed as unsafe, non-emergency.

The "unsafe" classification applied to a dam because of a "seriously inadequate spillway" is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that based on an initial screening and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream of the dam.

The stability analyses of the structure performed for this investigation indicate that the factors of safety against overturning and sliding are inadequate. The factor of safety against sliding was less than the recommended guidelines for one unloading condition.

b. Adequacy of Information - Available information and the observations and measurements made during the visual inspection are considered sufficient for this Phase I Inspection Report.

c. Need for Additional Investigation - Detailed hydrologic and hydraulic investigations of the watershed and reservoir area are considered necessary to more accurately determine the overtopping potential of the dam. After the in-depth hydrologic/hydraulic investigations have been completed, remedial measures must be initiated to provide spillway capacity sufficient to discharge the outflow from the 1/2 PMF event.

The three piping holes at the toe of the dam should be investigated to determine the cause of and needed remedial action, immediately. A detailed stability analysis of the dam is considered necessary to determine actual stability conditions.

d. Urgency - The detailed hydrologic and hydraulic investigations must be initiated within three months of notification to the owner. Within one year, remedial measures resulting from these investigations must be initiated, with completion of these measures during the following year. In the interim, a detailed emergency action plan must be developed and implemented during periods of unusually heavy precipitation. Also, around the clock surveillance must be provided during these periods.

7.2 RECOMMENDED MEASURES

Formal inspection and maintenance procedures should be developed with records maintained for future reference of inspection and maintenance completed. A thorough checklist should be compiled by the owner's representative and completed during each inspection. Maintenance items should be completed annually.

The following remedial measures must be completed within one year:

1. The seeps in the downstream face of the dam should be monitored to determine if seepage quantities are increasing.

2. The blow-off pipes should be made operable.

3. The mortar in the masonry joints in the downstream face should be repaired.

4. The valve house should be repaired.

5. The downstream channel below the spillway should be cleared of all obstructions to flow.

6. The three trees should be removed from the downstream face of the dam.

7. The concrete wing wall at the right abutment should be repaired.

8. The spalling on the upstream face of the concrete cap should be repaired.

9. All trees and brush at the downstream toe of the dam should be cut at ground level. The root systems of all trees with a trunk diameter greater than 3 inches should be removed. All resultant areas of erosion and cavities should be filled, compacted, and seeded.

APPENDIX A

PHOTOGRAPHS

CONTENTS

HILLBURN RESERVOIR DAM

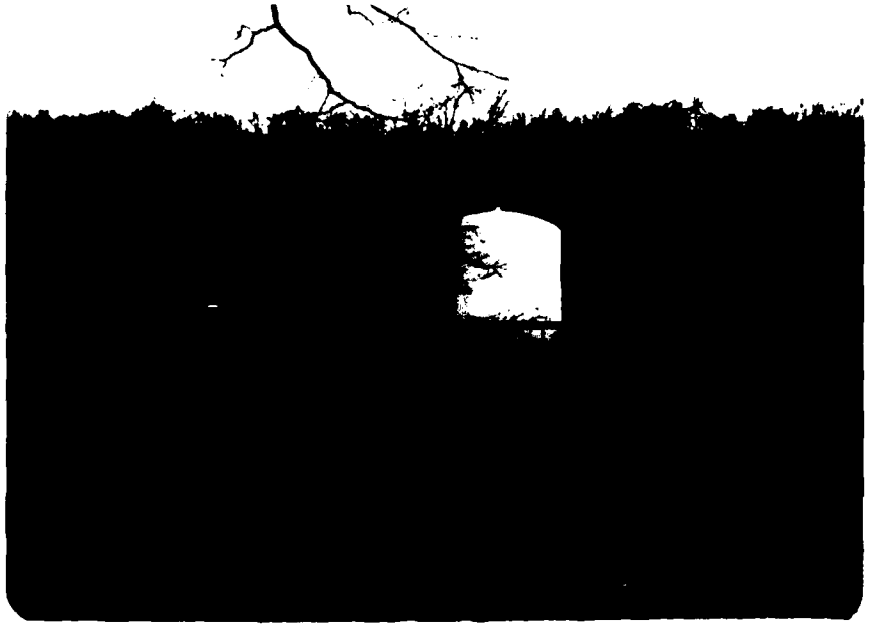


Photo 1. Upstream Face of Dam (Looking Toward Left Side of Dam)
10 March 1981

Photo 2. Downstream Face of Dam from Right Abutment
10 March 1981

Photo 3. Seep on Downstream Face of Dam Below Spillway
(Seep Obscured by Flow Over Spillway
During 10 March 1981 Inspection)
9 January 1981

Photo 4. Downstream Face of Dam from Below the Right Side of Spillway
(Seepage Area Obscured by Flow Over Spillway
During 10 March 1981 Inspection)
9 January 1981

Photo 5. 8-Inch Valves on Blow-Off Pipes
(Looking Upstream)
10 March 1981

Photo 6. Downstream Face of Dam Showing Deterioration of Mortar Joints in Dam and Seepage Under Concrete Cap
10 March 1981

Photo 7. Piping Hole at the Downstream Toe of the Dam
9 January 1981

APPENDIX B

VISUAL INSPECTION CHECKLIST

VISUAL INSPECTION CHECKLIST

1) Basic Data

a. General

Name of Dam Hillburn Reservoir Dam

Fed. I.D. # NY 974 DEC Dam No. 196-934

River Basin Passaic River

Location: Town Hillburn County Rockland

Stream Name Unnamed

Tributary of Ramapo River

Latitude (N) 41°07.53' Longitude (W) 74°11.03'

Type of Dam Gravity masonry dam with a concrete cap

Hazard Category High

Date(s) of Inspection 9 January 1981

Weather Conditions Cloudy, 15°F.

Reservoir Level at Time of Inspection 588.3 ft. M.S.L.

b. Inspection Personnel Wayne D. Lasch. Gary W. Todd, Rory L. Galloway

c. Persons Contacted (Including Address & Phone No.)

Allan Garfinkel, Village Hall

31 Mountain Avenue

Hillburn, NY 10931

914/357-0999

d. History:

Date Constructed Approx. 1906 Date(s) Reconstructed 1931

Designer Unknown

Constructed By Unknown

Owner Village of Hillburn, NY

2) Embankment - Note: Embankment only occurs on the downstream side of the left 219 ft. of the dam.

a. Characteristics

(1) Embankment Material The left 219 ft. of the dam consists of an embankment with a masonry wall on the upstream face.

(2) Cutoff Type

(3) Impervious Core Masonry wall with concrete cap on upstream side of embankment.

(4) Internal Drainage System None

(5) Miscellaneous Embankment only occurs on the downstream side of the left 219 ft. of the dam.

b. Crest - N.A.

(1) Vertical Alignment

(2) Horizontal Alignment

(3) Surface Cracks

(4) Miscellaneous

c. Upstream Slope - N.A

(1) Slope (Estimate) (V:H)

(2) Undesirable Growth or Debris, Animal Burrows

(3) Sloughing, Subsidence, or Depressions _____

(4) Slope Protection _____

(5) Surface Cracks or Movement at Toe _____

d. Downstream Slope

(1) Slope (Estimate - V:H) 1V:4H

(2) Undesirable Growth or Debris, Animal Burrows None observed at time of inspection.

(3) Sloughing, Subsidence or Depressions None observed at time of inspection.

(4) Surface Cracks or Movement at Toe None observed at time of inspection.

(5) Seepage None observed at time of inspection.

(6) External Drainage System (Ditches, Trenches, Blanket) None

(7) Condition Around Outlet Structure N/A

(8) Seepage Beyond Toe None observed at time of inspection.

e. Abutments - Embankment Contact No problems observed at time of inspection.

(1) Erosion at Contact

(2) Seepage Along Contact

3) Drainage System

a. Description of System None

b. Condition of System

c. Discharge from Drainage System

4) Instrumentation (Monumentation/Surveys, Observation Wells, Weirs, Piezometers, Etc.) None

5) Reservoir

a. Slopes Reservoir slopes are moderate to steep, rock covered, and wooded.

b. Sedimentation Owner's representative reported the depth of the reservoir at the spillway to be 18 ft., reduced from the original depth of 22 ft.

c. Unusual Conditions Which Affect Dam None observed at time of inspection.

6) Area Downstream of Dam

a. Downstream Hazard (No. of Homes, Highways, etc.) Nine houses within 2500 ft.

b. Seepage, Unusual Growth None observed at time of inspection.

c. Evidence of Movement Beyond Toe of Dam None observed at time of inspection.

d. Condition of Downstream Channel The channel has a moderate to steep slope with large boulders and debris in the channel.

7) Spillway(s) (Including Discharge Conveyance Channel)

a. General Three section concrete weir, 4 ft. breadth. Each weir section approximately 8 ft. long. Freeboard is only 0.7 ft.

b. Condition of Service Spillway Fair to good general condition. No deterioration observed. Two seeps, approximately 1/2 g.p.m. each, from bottom courses of masonry walls immediately below left and right edges of spillway. Numerous other minor seeps along bottom of masonry wall between the major seeps below the spillway.

c. Condition of Auxiliary Spillway None

d. Condition of Discharge Conveyance Channel Rocky, trees present, channel not well defined.

8) Reservoir Drain/Outlet

Type: Pipe 2 Conduit _____ Other _____

Material: Concrete _____ Metal cast iron Other _____

Size: 8 in. Length 68 ft.

Invert Elevations: Entrance Not observable

Exit 567.95 ft.

Physical Condition (Describe): Unobservable

Material: Cast iron pipe.

Joints: Tight Alignment Good

Structural Integrity: Appears to be in good condition.

Hydraulic Capability: One blow-off pipe is questionable since valve appears frozen.

Means of Control: Gate _____ Valve 8 in. Uncontrolled _____

Operation: Operable X Inoperable _____ Other _____

Present Condition (Describe): On downstream end, 1 valve is operable and the other appears to be frozen. Last operated 7-9 years ago.

9) Structural

a. Concrete Surfaces Concrete cap in good condition, small amount of spalling present on upstream face of cap.

b. Structural Cracking Mortar in masonry joints is generally deteriorated with many cracks and gaps, especially from spillway to right abutment.

c. Movement - Horizontal & Vertical Alignment (Settlement) None noted, good condition at time of inspection.

d. Junctions with Abutments or Embankments The wing wall at the extreme right end of the dam has collapsed.

e. Drains - Foundation, Joint, Face None

f. Water Passages, Conduits, Sluices None

g. Seepage or Leakage An apparent one inch piping hole was observed at the toe of the dam, at Sta. 0+55. Approximate flow 2-3 g.p.m. Removal of fines occurring. Also seepage below spillway (see 7b).

h. Joints - Construction, etc. Mortar joints in poor condition, holes penetrate up to 12 in. into dam. (Average penetration 4 in.). Local masonry loose.

i. Foundation Bedrock in vicinity of dam is reported to consist of pre-cambrian mixed gneisses, however foundation appears to be glacially deposited silt, sand, clay and boulders. A complete discussion will be addressed in the Geology Section.

j. Abutments No problems observed at time of inspection.

k. Control Gates None

l. Approach & Outlet Channels Outflow from spillway splashes over downstream face of dam to large boulders at base of spillway.

m. Energy Dissipators (Plunge Pool, etc.) Large boulders at base of spillway.

n. Intake Structures Unobservable at time of inspection.

o. Stability The stability is questionable, considering the poor condition of the structure.

p. Miscellaneous Three trees (2 in. to 5 in. diameter) are growing on the downstream masonry wall right of the spillway. Dam was snow covered at time of inspection (2-12 in.)

10) Appurtenant Structures (Power House, Lock, Gatehouse, Other)

a. Description and Condition Valve house (11 ft. x 13 ft.) located on upstream side of dam at Sta. 1+30. Foundation blocks, mortar is deteriorating with some missing. Building is in poor condition, wood plank floor has majority of boards missing.

APPENDIX C

HYDROLOGIC/HYDRAULIC ENGINEERING DATA AND COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HILLBURN RESERVOIR DAM S.O. No. _____
APPENDIX C - HYDROLOGIC / HYDRAULIC Sheet No. ____ of ____
_____ Drawing No. _____
Computed by _____ Checked by _____ Date _____

SUBJECT	PAGE

CHECK LIST FOR DAMS
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

AREA-CAPACITY DATA:

		Elevation * (ft.)	Surface Area (acres)	Storage Capacity (acre-ft.)
1)	Top of Dam	595.0	3.2	28.0
2)	Design High Water (Max. Design Pool)	-	-	-
3)	Auxiliary Spillway Crest	-	-	-
4)	Pool Level with Flashboards	N/A	-	-
5)	Service Spillway Crest	594.3	2.8	26.0

DISCHARGES

		Volume (cfs)
1)	Average Daily	Unknown
2)	Spillway @ Maximum High Water - Top of Dam -	37
3)	Spillway @ Design High Water	-
4)	Spillway @ Auxiliary Spillway Crest Elevation	-
5)	Low Level Outlet	12.20
6)	Total (of all facilities) @ Maximum High Water	43.1
7)	Maximum Known Flood	Unknown
8)	At Time of Inspection	0

*All elevations are referenced to the spillway crest, elevation 594.3 ft. M.S.L., estimated from the USGS topographic quadrangle for the area.

CREST: ELEVATION: 595.0

Type: Concrete

Width: 4 ft. Length: 476 ft.

Spillway Type 3 section, broad-crested weir.

Location on Dam 100 ft. from right abutment.

SPILLWAY:

SERVICE		AUXILIARY
594.3 ft.	Elevation	-
Broad-crested weir	Type	-
24 ft. (total)	Width	-
	Type of Control	
-	Uncontrolled	-
	Controlled:	
-	Type (Flashboards; gate)	-
-	Number	-
-	Size/Length	-
	Invert Material	-
	Anticipated Length of Operating Service	-
-	Chute Length	-
N.A	Height Between Spillway Crest & Approach Channel Invert (Weir Flow)	-

HYDROMETEROLOGICAL GAGES:

Type: None

Location: _____

Records:

Date: _____

Max. Reading: _____

FLOOD WATER CONTROL SYSTEM:

Warning System: None

_____

Method of Controlled Releases (mechanisms):

Two 8-in. cast iron blow-off pipes located beyond the toe of the dam.

_____

_____

DRAINAGE AREA: 0.53 sq.mi.

DRAINAGE BASIN RUNOFF CHARACTERISTICS:

Land Use - Type: Wooded

Terrain - Relief: Moderate to steep slopes.

Surface - Soil: Well drained.

Runoff Potential (existing or planned extensive alterations to existing surface or subsurface conditions)

There were no known plans for altering the existing runoff patterns at the time of the inspection.

Potential Sedimentation problem areas (natural or man-made; present or future)

None observed, all slopes well vegetated.

Potential Backwater problem areas for levels at maximum storage capacity including surcharge storage:

None observed at the time of the inspection.

Dikes - Floodwalls (overflow & non-overflow) - Low reaches along the Reservoir perimeter:

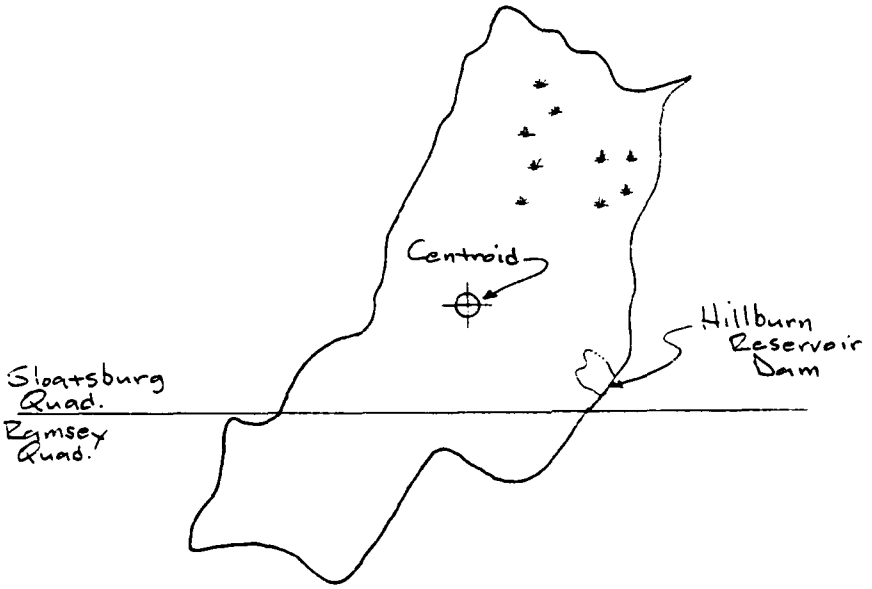
Location: None

Elevation:

Reservoir:

Length @ Maximum Pool 400 ft.

Length of Shoreline (@ Spillway Crest) 1450 ft. (0.27 Mi.)



HILLBURN RESERVOIR DAM
DRAINAGE AREA MAP

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Subject HILLBURN RESERVOIR DAM S.O. No. 16-02
HYDRAULIC DATA Sheet No. 6 of 26
Drawing No.
Computed by GWT Checked by WJL Date 1/15/81

STORAGE DATA

ELEVATION VS. SURFACE AREA

ELEVATION, (FT)	AREA, (ACRES) (MEASURED FROM USGS QUAD.)
594.3	2.8 (NORMAL POOL)
600.0	6.4
620.0	10.1

NORMAL POOL STORAGE IS 8.5 M.G. (26.09 AC-FT)
OBTAINED FROM THE RECORDS OF THE HILLBURN WATER DEPT.

$$\Delta E = \frac{3S}{RAREA(2)}$$

$$= \frac{3(26.09)}{2.8}$$

ΔE = 27.9 FT.

RELEV(1) = 594.3 - 27.9
= 566.4

FROM HEC-1 FLOOD HYDROGRAPH PACKAGE, USERS MANUAL, 1973 APPENDIX B P. B-31.

RELEV(2) = KNOWN STORAGE ELEVATION
RAREA(2) = AREA CORRESPONDING TO RELEV(2).
RELEV(1) = ELEVATION WHERE STORAGE IS ZERO
RELEV(1) = RELEV(2) - ΔE
RAREA(1) = 0
ΔE = CHANGE IN ELEVATION
S = KNOWN STORAGE AT RELEV(2) AND RAREA(2)

TOP OF DAM STORAGE

28 AC.-FT. (FROM HEC-1 ANALYSIS)

DRAINAGE AREA ~ 0.53 SQ. MI.

WATERSHED LENGTHS

L = 5125 FT. = 0.97 MI.
L_{CA} = 1275 FT. = 0.24 MI.

$T_p = C_T (L \times L_{CA})^{.3}$

C_p = 0.63 C_T = 2.0

$T_p = 2.0[(.97)(.24)]^{.3}$

= 1.29

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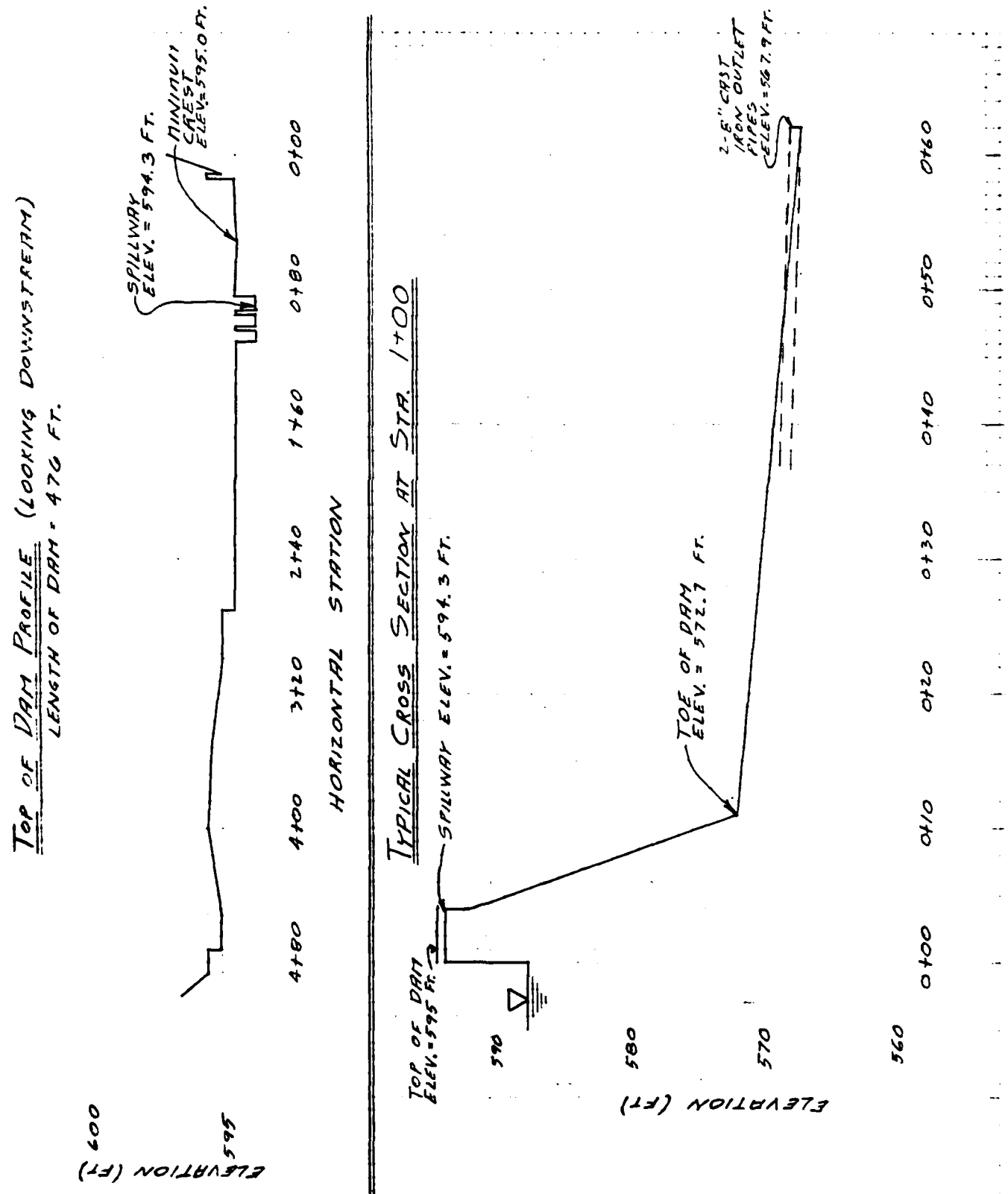
Subject HILLSVILLE RESERVOIR DAM S.O. No.
TOP OF DAM PROFILE AND Sheet No. 7 of 26
TYPICAL CROSS SECTION Drawing No.
Computed by GWT Checked by AJF Date 1/15/81



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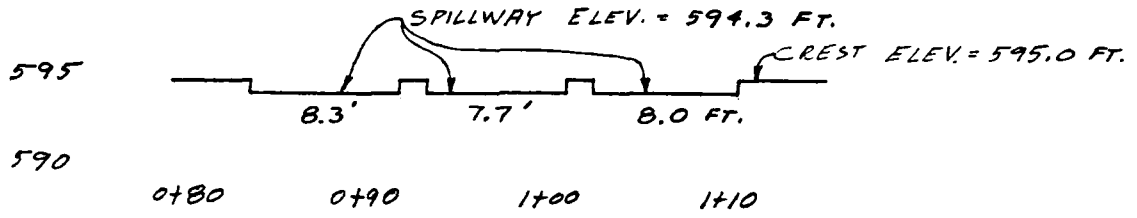
Subject HILLBURN RESERVOIR DAM S.O. No.
SPILLWAY RATING Sheet No. 8 of 26
Drawing No.
Computed by GWT Checked by MB Date 1/15/81

SPILLWAY PROFILE



SPILLWAY IS A BROAD-CRESTED WEIR 3 FEET WIDE.

$Q = CLH^{3/2}$ HANDBOOK OF HYDRAULICS, BRATER & KING, pg. 5-23.

C = 2.6 Pg. 5-40 BRATER & KING
L = TOTAL WEIR LENGTH = 24 FT.
H = MEASURED HEAD IN FEET

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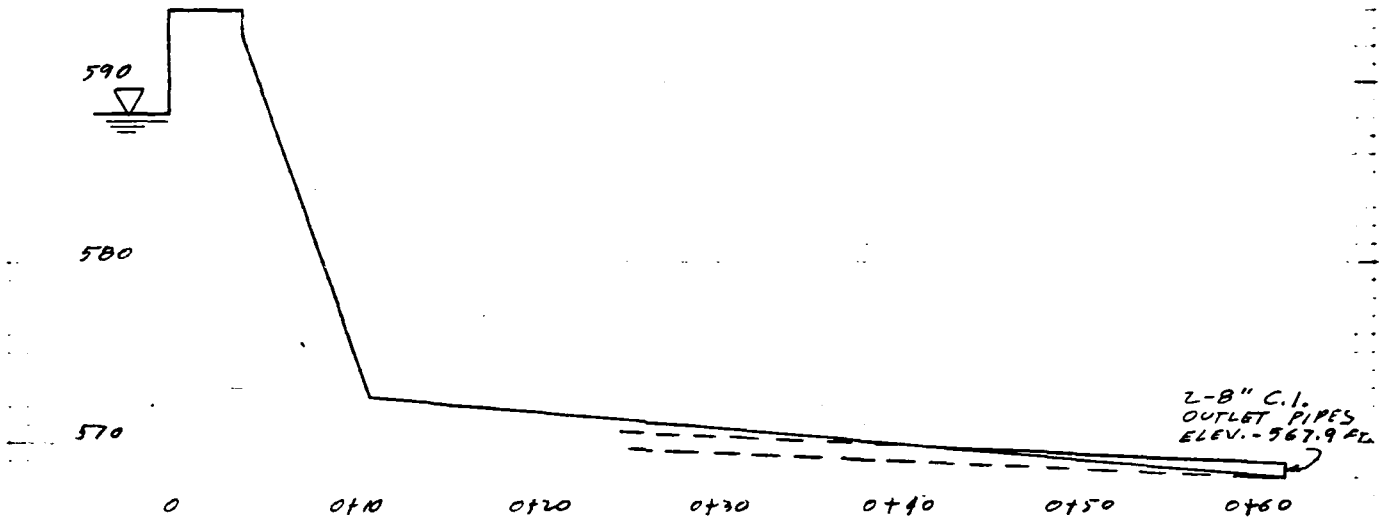
Subject HILLBURN RESERVOIR DAM S.O. No.
8" DIA. PIPE RATING Sheet No. 9 of 26
Drawing No.
Computed by GWT Checked by MB Date 1-26-81



SPILLWAY CREST ELEVATION - 594.3 FT.

INLET ELEVATION 8" PIPE - 573.0 FT. (ESTIMATED)

OUTLET ELEVATION 8" PIPE - 567.9 FT.

LENGTH OF 8" CAST IRON PIPE - 68 FT.

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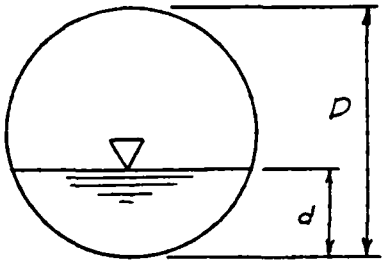
Subject HILLBURN RESERVOIR DAM S.O. No.
8" DIA. PIPE RATING Sheet No. 10 of 26
Drawing No.
Computed by GWT Checked by MB Date 1-26-81

"DESIGN OF SMALL DAMS" PG. 558 & 559



D = DIA. PIPE

d = DEPTH OF WATER

S = PIPE SLOPE

$= \frac{573.0 - 567.9}{68} = .0823$

n = .013

$\frac{d}{D} = \frac{.33}{.66} = .5$ TABLE B-2 $1.3955 = \frac{Q_c}{D^{5/2}} = \frac{Q_c}{(.66)^{5/2}}$ $Q = 3.94$ CFS

$\frac{d}{D} = \frac{.33}{.66} = .5$ TABLE B-3 $.232 = \frac{Q_n}{D^{8/3} S^{1/2}} = \frac{Q(.013)}{(.66)^{8/3}(.0823)^{1/2}}$ $Q = 1.69$ CFS

$\frac{d}{D} = \frac{.5}{.66} = .76$ TABLE B-2 $3.1450 = \frac{Q_c}{D^{5/2}} = \frac{Q_c}{(.66)^{5/2}}$ $Q = 8.89$ CFS

$\frac{d}{D} = \frac{.5}{.66} = .76$ TABLE B-3 $.429 = \frac{Q_n}{D^{8/3} S^{1/2}} = \frac{Q(.013)}{(.66)^{8/3}(.0823)^{1/2}}$ $Q = 3.13$ CFS

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Subject HILLBURN RESERVOIR DAM S.O. No. _____
8" DIA. PIPE RATING Sheet No. 11 of 26
_____ Drawing No. _____
Computed by GWT Checked by ~~AHB~~ Date 1-26-81

ORIFICE FLOW

$Q = CA(2gH)^{.5}$

$= .60(0.34)(2 \times 32.2 H)^{.5}$

$= 1.642\ H^{.5}$

$A = \pi R^2 = \pi(.33)^2 = 0.342$ SQ. FT.

$g = 32.2$ FT/SEC^2

H VARIES FROM 0.3 FT TO 26.1 FT AND IS MEASURED TO THE CENTER OF THE PIPE

C = .60 FROM TABLE 4-6 Pg. 4-32 BRATER & KING

ELEVATION, (FT)	H, (FT)	Q, (CFS)
575.0	1.7	2.14
576.0	2.7	2.69
578.0	4.7	3.56
580.0	6.7	4.25
582.0	8.7	4.84
584.0	10.7	5.37
586.0	12.7	5.85
588.0	14.7	6.29
590.0	16.7	6.71
592.0	18.7	7.10
594.0	20.7	7.47
594.3	21.0	7.52

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Subject HILLBURN RESERVOIR DAM S.O. No.
8" DIA. PIPE FLOW Sheet No. 12 of 26
Drawing No.
Computed by GWT Checked by [illegible] Date 1-26-81

PIPE FLOW

$$Q = \frac{A(2gH)^{1/2}}{[1 + K_e + K_b + K_c(L)]^{1/2}}$$

$$= \frac{(.342)(64.4\,H)^{1/2}}{[1 + .78 + 0 + (.0537)(68)]^{1/2}}$$

$$= 1.1776\,H^{1/2}$$

$A = \pi R^2 = \pi(.33)^2 = .342$ SQ. FT.
$g = 32.2$ FT/SEC^2
H VARIES AND IS MEASURED FROM THE TOP OF THE PIPE AT THE OUTLET.
$L = 68$ FT.
$K_e (K_o) = .78$ Pg. 5.5-6 SCS NEH-5
$K_b (K_s) = 0$ Pg. 5.5-10 SCS NEH-5
$K_c (K_p) = 0.0537$ Pg. 5.5-4 SCS NEH-5
$n = 0.013$

TOP OF 8" CAST IRON PIPE AT OUTLET ELEV = 567.5 FT.

ELEVATION, (FT)	H, (FT)	Q, (CFS)
574.0	6.5	3.00
576.0	8.5	3.43
578.0	10.5	3.82
580.0	12.5	4.16
582.0	14.5	4.48
584.0	16.5	4.78
586.0	18.5	5.06
588.0	20.5	5.33
590.0	22.5	5.59
592.0	24.5	5.83
594.0	26.5	6.06
594.3	26.8	6.10

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

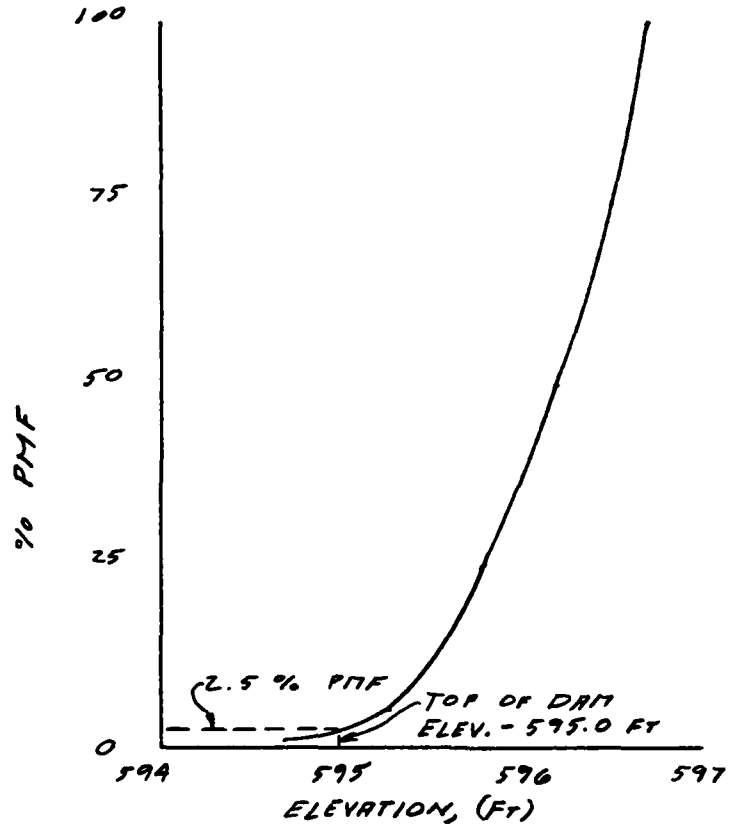
Subject HILLBURN RESERVOIR DAM S.O. No.
8" DIA. PIPE RATING SUMMARY Sheet No. 13 of 26
Drawing No.
Computed by GWT Checked by HMB Date 1-30-81

ELEVATION (FT)	Q (CFS)	TOTAL Q 2 PIPES. (CFS)
573.0	0	0
573.3	1.69	3.38
575.0	2.14	4.28
576.0	2.69	5.38
578.0	3.56	7.12
580.0	4.16	8.32
582.0	4.48	8.96
584.0	4.78	9.56
586.0	5.06	10.12
588.0	5.33	10.66
590.0	5.59	11.18
592.0	5.83	11.66
594.0	6.06	12.12
594.3	6.10	12.20

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HILLBURN RESERVOIR DAM S.O. No.
SPILLWAY CAPACITY ANALYSIS Sheet No. 14 of 26
Drawing No.
Computed by GWT Checked by Date 2-11-81



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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DA1 SAFETY VERSION     JULY 1978
  LAST MODIFICATION  26 FEB 79
  ADD UPDATE         04 JUL 79    Flood Routing
**********
    1          A1       NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
    2          A2       HYDROLOGIC AND HYDRAULIC ANALYSIS OF HILLBURN RESERVOIR DAM
    3          A3       UNIT HYDROGRAPH BY SNYDERS METHOD
    4          B    300       3       5       0       0       0       0      -4       0
    5          B1     3
    6          J      1       3       1
    7          J1   1.3    0.75     0.5    0.25    0.01
    8          K      3       1                               1
    9          K1       ROUTE HYDROGRAPH TO DAM
   10          M      1       1    0.53
   11          P              21.9     111     123     133     142
   12          T                                                      1.0    0.05
   13          W   1.27     .03
   14          X   -1.3   -0.03     2.0
   15          K      1       2                               1
   16          K1       ROUTING FOR HILLBURN RESERVOIR DAM
   17          Y                                       1       1
   18          Y1     1                                               -594.3       0
   19          $A   .17     2.3     6.4    10.1
   20          $E   573     594.3   600     620
   21          $$ 594.3     24.3     2.6     1.5
   22          $D 593.3      2.0     1.5     452
   23          $L     3      232     232     342     432     485
   24          $V 595.0   595.3   596.0   596.5   597.0   597.5
   25          K     77
```

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
48J UPDATE 04 JUN 79
****

RUN DATE 22/12/01
TIME 14.37

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
HYDROLOGIC AND HYDRAULIC ANALYSIS OF HILLSDALE RESERVOIR DAM
JOIT HYDROGRAPH BY SNYDERS METHOD

JOB SPECIFICATION

NQ	NDS	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
600	3	5	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	3

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 5 LRTIO= 1
RTIOS= 1.00 0.75 0.50 0.25 0.01

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RUNOFF HYDROGRAPH TO DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYD	HUNO	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISAME	ISAME	LOCAL
1	1	0.53	0.0	0.53	0.0	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	21.90	111.00	123.00	133.00	142.00	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.000

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOR	STRTL	CNSTL	ALSMX	RTIMP
0	0.0	0.0	1.00	0.0	0.0	1.00	1.00	0.00	0.0	0.0

UNIT HYDROGRAPH DATA
TP= 1.29 CP=0.63 NTA= 0

RECESSION DATA
STRTQ= -1.00 QRCSN= -0.05 RTIOR= 2.00

UNIT HYDROGRAPH 35 END-OF-PERIOD ORDINATES, LAG= 1.28 HOURS, CP= 0.63 VOL= 1.00

3.	11.	22.	35.	50.	65.	82.	94.	100.	132.
165.	193.	189.	173.	173.	172.	166.	159.	150.	138.
129.	123.	112.	104.	97.	90.	84.	79.	73.	68.
64.	59.	55.	52.	48.	45.	42.	39.	36.	34.

Sheet 16 of 26

```
   31.       29.       27.       26.       24.       22.       21.       19.       18.       17.
   16.       15.       14.       13.       12.       11.       10.       10.        9.        8.
    8.        7.        7.        6.        6.        5.        5.        5.        4.        4.
    4.        4.        3.        3.        3.        3.        3.        2.        2.        2.
    2.        2.        2.        2.        1.

                                        END-OF-PERIOD FLOW
     0
 MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP Q      MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS    COMP Q

                                                                         SUM  24.80  22.48   2.39   91026.
                                                                            ( 632.)( 571.)(  61.)( 2594.50)


        **********        **********        **********        **********        **********

                                         HYDROGRAPH ROUTING

                  ROUTING FOR HILLBURN RESERVOIR DAM

                            ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                                2       1       0       0       0       0       1       0       0
                                                  ROUTING DATA
                    QLOSS   CLOSS     AVG    IRES   ISAME    IOPT    IPMP            LSTR
                      0.0     0.0     0.0       1       1       0       0               0

                            NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                                1       0       0     0.0     0.0     0.0   -594.       0

 SURFACE AREA=        0.       3.       6.      10.

     CAPACITY=        0.      26.      52.     215.

    ELEVATION=      573.     594.     600.     620.

                          CREL   SPWID   COQW   EXPW   ELEVL   COOL   CAREA   EXPL
                         594.3    24.0    2.6    1.5     0.0    0.0     0.0    0.0

                                                 DAM DATA
                                         TOPEL   COQD   EXPD  DAMWID
                                         595.0    2.6    1.5    452.

    CREST LENGTH       0.      232.      232.      342.      432.      485.
    AT OR BELOW
    ELEVATION      595.0     595.5     596.0     596.5     597.0     597.5

 PEAK OUTFLOW IS    1569. AT TIME  40.83 HOURS

 PEAK OUTFLOW IS    1248. AT TIME  40.83 HOURS

 PEAK OUTFLOW IS     831. AT TIME  40.83 HOURS

 PEAK OUTFLOW IS     415. AT TIME  40.83 HOURS

 PEAK OUTFLOW IS      14. AT TIME  41.33 HOURS

        **********        **********        **********        **********        **********
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SHEET 17 OF 26

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00	RATIO 2 0.75	RATIO 3 0.50	RATIO 4 0.25	RATIO 5 0.01
HYDROGRAPH AT	1	0.55	1	1664.	1248.	832.	416.	17.
		1.37)		47.13)(	35.34)(	23.56)(	11.78)(	0.47)(
ROUTED TO	2	0.55	1	1664.	1248.	831.	415.	14.
		1.37)		47.12)(	35.34)(	23.54)(	11.77)(	0.40)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	594.30	594.30	598.00
STORAGE	20.	20.	28.
OUTFLOW	0.	0.	37.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	595.74	1.74	39.	10000.	13.42	40.83	0.0
0.75	595.50	1.50	35.	8243.	10.67	40.83	0.0
0.50	595.20	1.20	32.	6316.	14.42	40.83	0.0
0.25	595.81	0.81	31.	4152.	8.83	40.83	0.0
0.01	594.57	0.0	27.	19.	0.0	41.33	0.0

THE SDF IS ½ PMF

SHEET 19 OF 26

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1973
  LAST MODIFICATION  26 FEB 79
  ABBJ UPDATE        04 JUN 79
**********
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Dewatering Analysis

```
    1              A1       NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
    2              A2       HYDROLOGIC AND HYDRAULIC ANALYSIS OF HILLBURN RESERVOIR DAM
    3              A3       DEWATERING ANALYSIS OF HILLBURN RESERVOIR DAM
    4              B    100         1         0         0         0         0         0         0         0         0
    5              B1     .
    6              J     1         1         1
    7              J1    1
    8              K                1                                       1
    9              K1       RUNOFF HYDROGRAPH TO DAM
   10              H     -1                0.53                  0.53                                    1
   11              N
   12              N
   13              N
   14              N
   15              N
   16              N
   17              N
   18              N
   19              N
   20              N
   21              K     1         2                                       1
   22              K1       DEWATERING HILLBURN RESERVOIR DAM
   23              Y                                     1         1
   24              Y1    1                                                       -596.3        -1
   25              Y4    573       573.3     575       576       578       580       582       584       586       588
   26              Y4    593       592       594       594.3
   27              Y5      1       3.38      4.23      5.38      7.12      8.32      8.96      9.56      10.12     10.66
   28              Y5    11.13     11.66     12.12     12.20
   29              $A    0.17      2.3       6.4       13.10
   30              $E    573       594.3     600       620
   31              $S    594.3
   32              $D    573       2.0       1.5       452
   33              K     77
```

SHEET 20 OF 26

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION        JULY 1978
  LAST MODIFICATION  26 FEB 79
  RAN UPDATE          04 JUN 79
**********************************

RUN  DATE 02/13/81
     TIME    08.02
```

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
HYDROLOGIC AND HYDRAULIC ANALYSIS OF HILLBURN RESERVOIR DAM
DEWATERING ANALYSIS OF HILLBURN RESERVOIR DAM

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
100	1	0	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 1

RTIOS=   1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW RUNOFF HYDROGRAPH TO DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	0.53	0.0	0.53	0.0	0.0	0	1	0

INPUT HYDROGRAPH

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	0.	0.	0.	0.	0.
CMS	0.	0.	0.	0.	0.
INCHES		0.0	0.0	0.0	0.0
MM		0.0	0.0	0.0	0.0
AC-FT		0.	0.	0.	0.
THOUS CU M		0.	0.	0.	0.

```
                         HYDROGRAPH AT STA     1 FOR PLAN 1, RTIO 1
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.
   0.       0.       0.       0.       0.       0.       0.       0.       0.       0.

                     PEAK    6-HOUR   24-HOUR   72-HOUR   TOTAL VOLUME
            CFS        0.        0.        0.        0.          0.
            CMS        0.        0.        0.        0.          0.
         INCHES                 0.0       0.0       0.0         0.0
             MM                 0.0       0.0       0.0         0.0
          AC-FT                  0.        0.        0.          0.
      THOUS CU M                 0.        0.        0.          0.


   **********         **********         **********         **********         **********

                                   HYDROGRAPH ROUTING

            DEWATERING HILLBURN RESERVOIR DAM

                 ISTAQ   ICOMP   IECON   ITAPE   JPLT    JPRT   INAME  ISTAGE   IAUTO
                     2       1       0       0      0       0       1       0       0
                                       ROUTING DATA
          QLOSS   CLOSS     AVG    IRES   ISAME   IOPT    IPMP            LSTR
            0.0     0.0     0.0       1       1      0       0               0

                 NSTPS   NSTDL     LAG   AMSKK       X     TSK   STORA  ISPRAT
                     1       0       0     0.0     0.0     0.0   -594.      -1

STAGE      573.00   573.30   575.00   576.00   578.00   580.00   582.00   584.00   586.00   588.00
           590.30   592.30   594.00   594.30

FLOW         0.0     3.38     4.28     5.38     7.12     8.32     8.96     9.56    10.12    10.66
           11.18    11.56    12.12    12.20

SURFACE AREA=      0.       3.       6.      10.

   CAPACITY=       0.      26.      52.     215.

  ELEVATION=     573.     594.     600.     620.

                 CREL    SPWID    COQW    EXPW    ELEVL    COQL    CAREA    EXPL
                594.3      0.0     0.0     0.0      0.0     0.0      0.0     0.0

                                          DAM DATA
                                  TOPEL    COQD    EXPD   DAMWID
                                  595.0     2.6     1.5     452.

                                  STATION      2, PLAN 1, RATIO 1

                               END-OF-PERIOD HYDROGRAPH ORDINATES
                 MO.DA  HR.MN  PERIOD  HOURS    INFLOW   OUTFLOW   STORAGE     STAGE

                  1.01   1.00       1   1.00       0.       17.       25.     593.9
```

1.31	2.00	2	2.00	0.	12.	24.	593.6
1.31	3.00	3	3.00	0.	12.	23.	593.2
1.31	4.00	4	4.00	0.	12.	22.	592.8
1.31	5.00	5	5.00	0.	12.	21.	592.4
1.31	6.00	6	6.00	0.	12.	20.	592.0
1.31	7.00	7	7.00	0.	12.	19.	591.6
1.31	8.00	8	8.00	0.	11.	18.	591.2
1.31	9.00	9	9.00	0.	11.	17.	590.7
1.31	10.00	10	10.00	0.	11.	16.	590.3
1.31	11.00	11	11.00	0.	11.	15.	589.8
1.31	12.00	12	12.00	0.	11.	14.	589.4
1.31	13.00	13	13.00	0.	11.	14.	588.9
1.31	14.00	14	14.00	0.	11.	13.	588.4
1.31	15.00	15	15.00	0.	11.	12.	587.9
1.31	16.00	16	16.00	0.	10.	11.	587.4
1.31	17.00	17	17.00	0.	10.	10.	586.8
1.31	18.00	18	18.00	0.	10.	9.	586.2
1.31	19.00	19	19.00	0.	10.	8.	585.6
1.31	20.00	20	20.00	0.	10.	8.	585.0
1.31	21.00	21	21.00	0.	10.	7.	584.3
1.31	22.00	22	22.00	0.	9.	6.	583.6
1.31	23.00	23	23.00	0.	9.	5.	582.8
1.32	0.0	24	24.00	0.	9.	4.	582.1
1.32	1.00	25	25.00	0.	9.	4.	581.2
1.32	2.00	26	26.00	0.	8.	3.	580.3
1.32	3.00	27	27.00	0.	8.	2.	579.2
1.32	4.00	28	28.00	0.	7.	2.	578.1
1.32	5.00	29	29.00	0.	6.	1.	576.9
1.32	6.00	30	30.00	0.	5.	1.	575.7
1.32	7.00	31	31.00	0.	4.	0.	574.4
1.32	8.00	32	32.00	0.	2.	0.	573.2
1.32	9.00	33	33.00	0.	0.	0.	573.0
1.32	10.00	34	34.00	0.	0.	0.	573.0
1.32	11.00	35	35.00	0.	0.	0.	573.0
1.32	12.00	36	36.00	0.	0.	0.	573.0
1.32	13.00	37	37.00	0.	0.	0.	573.0
1.32	14.00	38	38.00	0.	0.	0.	573.0
1.32	15.00	39	39.00	0.	0.	0.	573.0
1.32	16.00	40	40.00	0.	0.	0.	573.0
1.32	17.00	41	41.00	0.	0.	0.	573.0
1.32	18.00	42	42.00	0.	0.	0.	573.0
1.32	19.00	43	43.00	0.	0.	0.	573.0
1.32	20.00	44	44.00	0.	0.	0.	573.0
1.32	21.00	45	45.00	0.	0.	0.	573.0
1.32	22.00	46	46.00	0.	0.	0.	573.0
1.32	23.00	47	47.00	0.	0.	0.	573.0
1.33	0.0	48	48.00	0.	0.	0.	573.0
1.33	1.00	49	49.00	0.	0.	0.	573.0
1.33	2.00	50	50.00	0.	0.	0.	573.0
1.33	3.00	51	51.00	0.	0.	0.	573.0
1.33	4.00	52	52.00	0.	0.	0.	573.0
1.33	5.00	53	53.00	0.	0.	0.	573.0
1.33	6.00	54	54.00	0.	0.	0.	573.0
1.33	7.00	55	55.00	0.	0.	0.	573.0
1.33	8.00	56	56.00	0.	0.	0.	573.0
1.33	9.00	57	57.00	0.	0.	0.	573.0
1.33	10.00	58	58.00	0.	0.	0.	573.0
1.33	11.00	59	59.00	0.	0.	0.	573.0
1.33	12.00	60	60.00	0.	0.	0.	573.0
1.33	13.00	61	61.00	0.	0.	0.	573.0
1.33	14.00	62	62.00	0.	0.	0.	573.0
1.33	15.00	63	63.00	0.	0.	0.	573.0
1.33	16.00	64	64.00	0.	0.	0.	573.0
1.33	17.00	65	65.00	0.	0.	0.	573.0
1.33	18.00	66	66.00	0.	0.	0.	573.0
1.33	19.00	67	67.00	0.	0.	0.	573.0

1.33	20.00	68	69.00	0.	0.	0.	573.0
1.33	21.00	69	69.00	0.	0.	0.	573.0
1.33	22.00	70	70.00	0.	0.	0.	573.0
1.33	23.00	71	71.00	0.	0.	0.	573.0
1.34	0.0	72	72.00	0.	0.	0.	573.0
1.34	1.00	73	73.00	0.	0.	0.	573.0
1.34	2.00	74	74.00	0.	0.	0.	573.0
1.34	3.00	75	75.00	0.	0.	0.	573.0
1.34	4.00	76	76.00	0.	0.	0.	573.0
1.34	5.00	77	77.00	0.	0.	0.	573.0
1.34	6.00	78	78.00	0.	0.	0.	573.0
1.34	7.00	79	79.00	0.	0.	0.	573.0
1.34	8.00	80	80.00	0.	0.	0.	573.0
1.34	9.00	81	81.00	0.	0.	0.	573.0
1.34	10.00	82	82.00	0.	0.	0.	573.0
1.34	11.00	83	83.00	0.	0.	0.	573.0
1.34	12.00	84	84.00	0.	0.	0.	573.0
1.34	13.00	85	85.00	0.	0.	0.	573.0
1.34	14.00	86	86.00	0.	0.	0.	573.0
1.34	15.00	87	87.00	0.	0.	0.	573.0
1.34	16.00	88	88.00	0.	0.	0.	573.0
1.34	17.00	89	89.00	0.	0.	0.	573.0
1.34	18.00	90	90.00	0.	0.	0.	573.0
1.34	19.00	91	91.00	0.	0.	0.	573.0
1.34	20.00	92	92.00	0.	0.	0.	573.0
1.34	21.00	93	93.00	0.	0.	0.	573.0
1.34	22.00	94	94.00	0.	0.	0.	573.0
1.34	23.00	95	95.00	0.	0.	0.	573.0
1.35	0.0	96	96.00	0.	0.	0.	573.0
1.35	1.00	97	97.00	0.	0.	0.	573.0
1.35	2.00	98	98.00	0.	0.	0.	573.0
1.35	3.00	99	99.00	0.	0.	0.	573.0
1.35	4.00	100	100.00	0.	0.	0.	573.0

PEAK OUTFLOW IS 12. AT TIME 0.0 HOURS

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	12.	12.	11.	4.	303.
CMS	0.	0.	0.	0.	9.
INCHES		0.21	0.75	0.89	0.89
MM		5.28	19.13	22.50	22.50
A.-FT		6.	21.	25.	25.
THOUS CU M		7.	26.	31.	31.

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1
				1.00
HYDROGRAPH AT	1	3.53	1	0.
	(	1.37)	(	0.0)
ROUTED TO	2	3.53	1	12.
	(	1.37)	(	0.34)

RATIOS APPLIED TO FLOWS

SHEET 25 OF 26

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	594.30	594.30	595.00
STORAGE	26.	26.	28.
OUTFLOW	12.	12.	12.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	593.94	0.0	26.	12.	0.0	0.0	0.0

Sheet 26 of 26

APPENDIX D

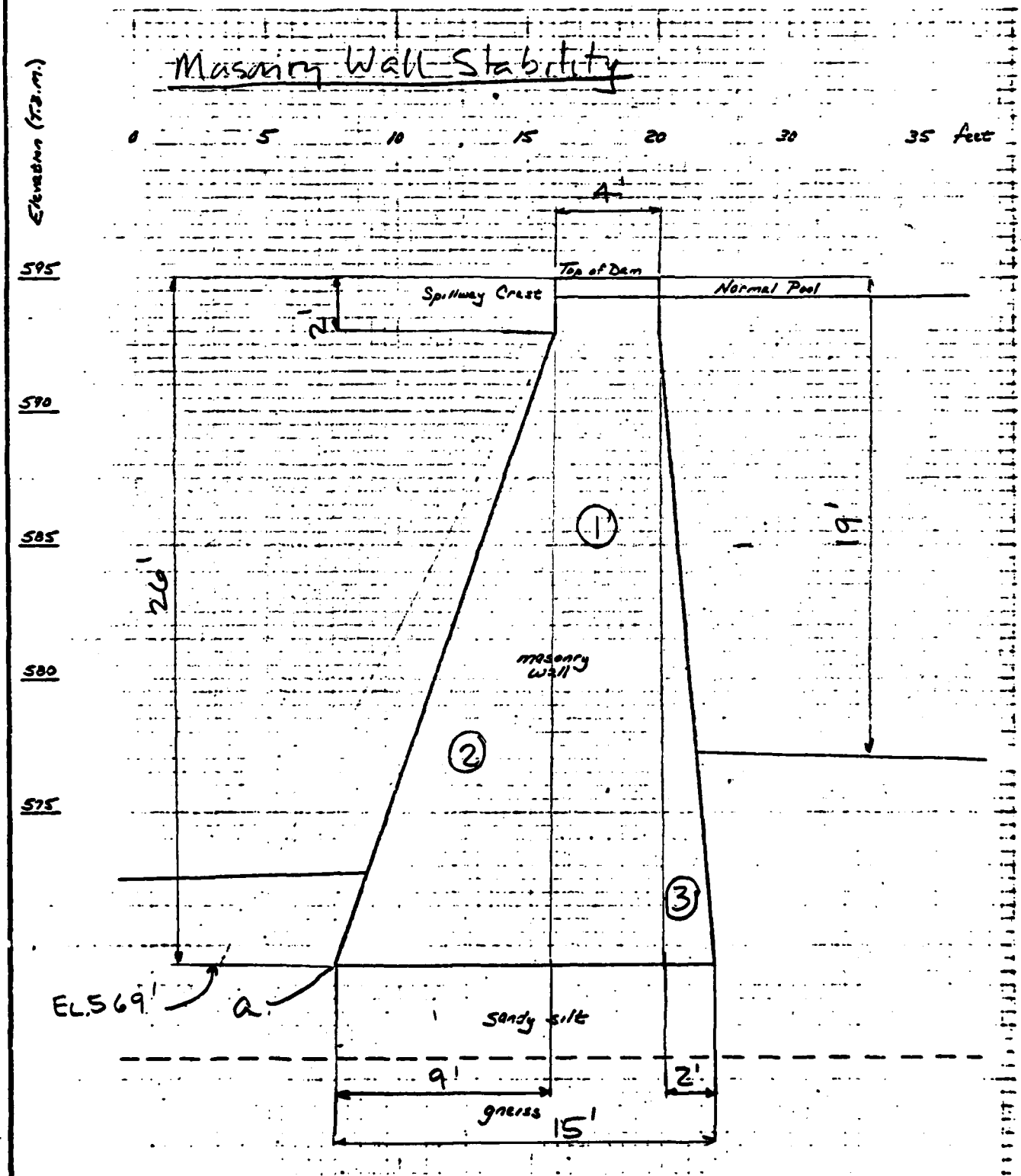
STABILITY COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HILLBURN RESERVOIR DAM — S.O. No. 13998
STABILITY ANALYSIS — Sheet No. 1 of 11
MAXIMUM DAM SECTION AT SPILLWAY — Ref Drawing No. HR 1
Computed by DWH — Checked by _____ — Date Feb 1981

Masonry Wall Stability



MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Hillburn Reservoir Dam S.O. No. 13999
STABILITY ANALYSIS Sheet No. 2 of 11
Ref Drawing No. HR2
Computed by JT Checked by _____ Date Feb. 1981

ΣMa Masonry Wall Structure

	Area	W	Dist from Toe	M
①	$4' \times 26' = 104 FT^2 @ .14$	$= 14.6^k$	$11'$	$161\ ^{'k}$
②	$24' \times 9' \times \frac{1}{2} = 108 FT^2 @ .14$	$= 15.1^k$	$6'$	$91\ ^{'k}$
③	$24' \times 2' \times \frac{1}{2} = 24 FT^2 @ .14$	$= 3.4^k$	$13.7'$	$47\ ^{'k}$
		33.1^k		$299\ ^{'k}$

$\bar{x} = 299 \div 33.1 = 9'$

Middle Third = 5' to 10' from a

For Soil Pressure $< \frac{15}{6} = 2.5$ OK

$e = 9 - \frac{15}{2} = 1.5$ $P = 33.1^k$

$$p = \frac{P}{b}\left(1 \pm \frac{6e}{b}\right)$$

$$p = \frac{33.1}{15}\left(1 \pm \frac{6 \times 1.5}{15}\right)$$

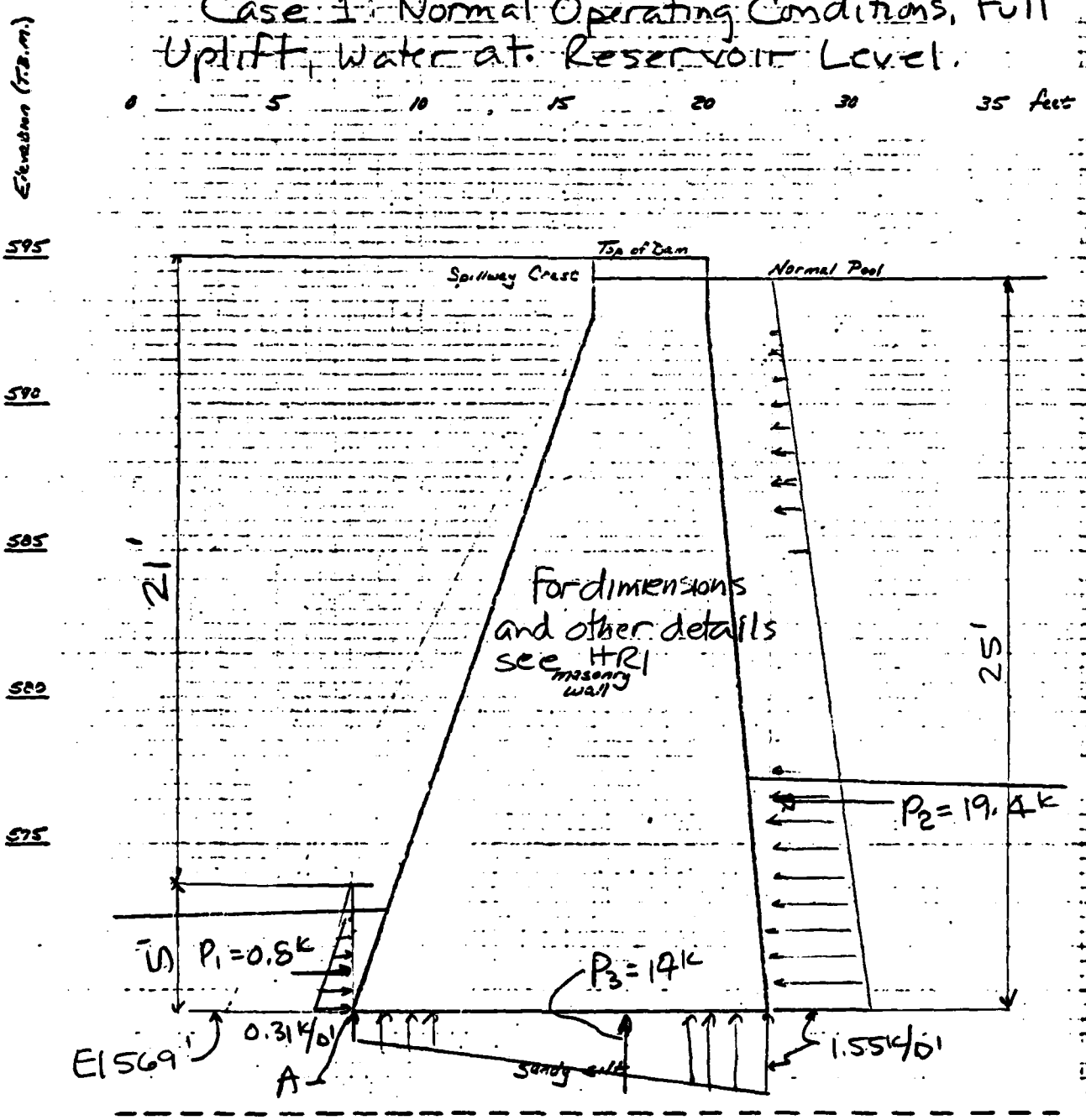
$p_{min} = 0.88$ ksf $p_{max} = 3.53$ ksf

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: HILLEVAH RESERVOIR DAM — S.O. No. 13988
STABILITY ANALYSIS — Sheet No. 3 of 11
MAXIMUM DAM SECTION AT SPILLWAY — Ref Drawing No. HR3
Computed by DWH — Checked by _____ — Date Feb 1981

Case 1: Normal Operating Conditions, Full Uplift, Water at Reservoir Level.



$P_1 = 5' \times 0.062\,k/o' = 0.31$
$P_2 = 25' \times 0.062\,k/o' = 1.55\,k/o'$ gneiss

$P_2 = 1.55\,k/o' \times 25 \times \frac{1}{2} = 19.4^k$
$P_1 = 0.31\,k/o' \times 5 \times \frac{1}{2} = 0.8^k$
$P_3 = 0.31 \times 15 + (1.55 - 0.31) \times \frac{15}{2} = 14^k$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Hillburn Reservoir Dam S.O. No. 13855
STABILITY ANALYSIS Sheet No. 4 of 11
Ref Drawing No. HR4
Computed by JT Checked by _____ Date Feb 1981

ΣM_A see Ref No HR3 Case 1

	W	Arm	M
① to ③	33.1K ↓		299'K
P_2	19.4K ←	25/3	- 161'K
P_1	0.8K →	5/3	+ 1'K
Uplift P_3	5.0K ↑	15/2	- 38'K
	9.0K ↑	2×15/3	- 90'K
	19.1K ↓		11'K
	18.6K ←		

$\bar{X}$ from A = 11'K ÷ 19.1K = 0.57' Not in Middle Third

FS against OT = $\frac{300}{289}$ = 1.04

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Hillburn Reservoir Dam S.O. No. 13888
STABILITY ANALYSIS Sheet No. 5 of 11
Ref Drawing No. HRS
Computed by JT Checked by _____ Date Feb 1981

Case 2 Case 1 with an ice load of 5^k at Operating Level. See HR3 for Ice Location from A.

ΣM_A	W	arm	M
Case 1	↓ 19.1^k		11'k
	← 18.6^k		
Ice Load	← 5^k	- 25'	- 125'k
			- 114'k

$\Sigma V = 19.1^k \downarrow$

$\Sigma H = 23.6^k \leftarrow$

$\bar{x} = 114'^k \div 19.1^k = -6.0'$

FS against OT = $\frac{300}{414} = 0.72$

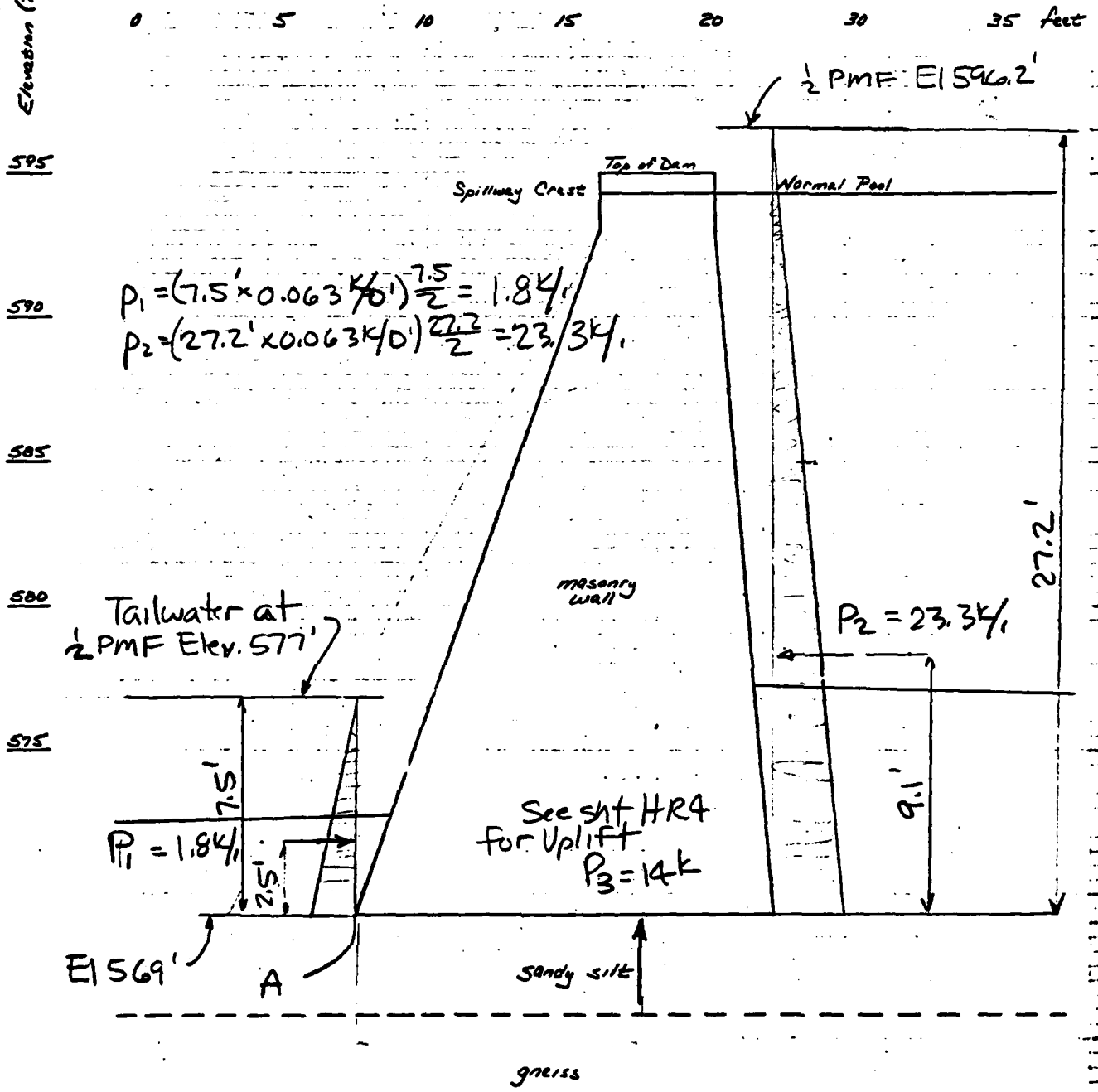
MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HILLBUAN RESERVOIR DAM
STABILITY ANALYSIS
MAXIMUM DAM SECTION AT SPILLWAY

S.O. No. 13888
Sheet No. 6 of 11
Ref Drawing No. HR6
Computed by DWH/JJ Checked by _____ Date Feb 1981

Case 3 - Reservoir level during ½ PMF
El 596.2 with full uplift and 45' tailwater



MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HILLBURN RESERVOIR DAM S.O. No. 13666
STABILITY ANALYSIS Sheet No. 7 of 11
Drawing No. HR 7
Computed by JT Checked by _____ Date Feb 1981

Case 3 - Reservoir Level ½ PMF, full uplift, and 45' tailwater.

	ΣMA	W	arm	M	
① to ③		33.1K ↓		299'k	
Uplift		14.0K ↑		-128'k	+304
Water Pr					-340
	P_1	1.8K →	+2.5'	5'k	
	P_2	23.3K ←	-9.1'	-212'k	
		ΣV = 19.1 ↓		-36'k	
		ΣH = 21.5 ←			

$\bar{X} = -36 \div 19.1 = -1.9'$

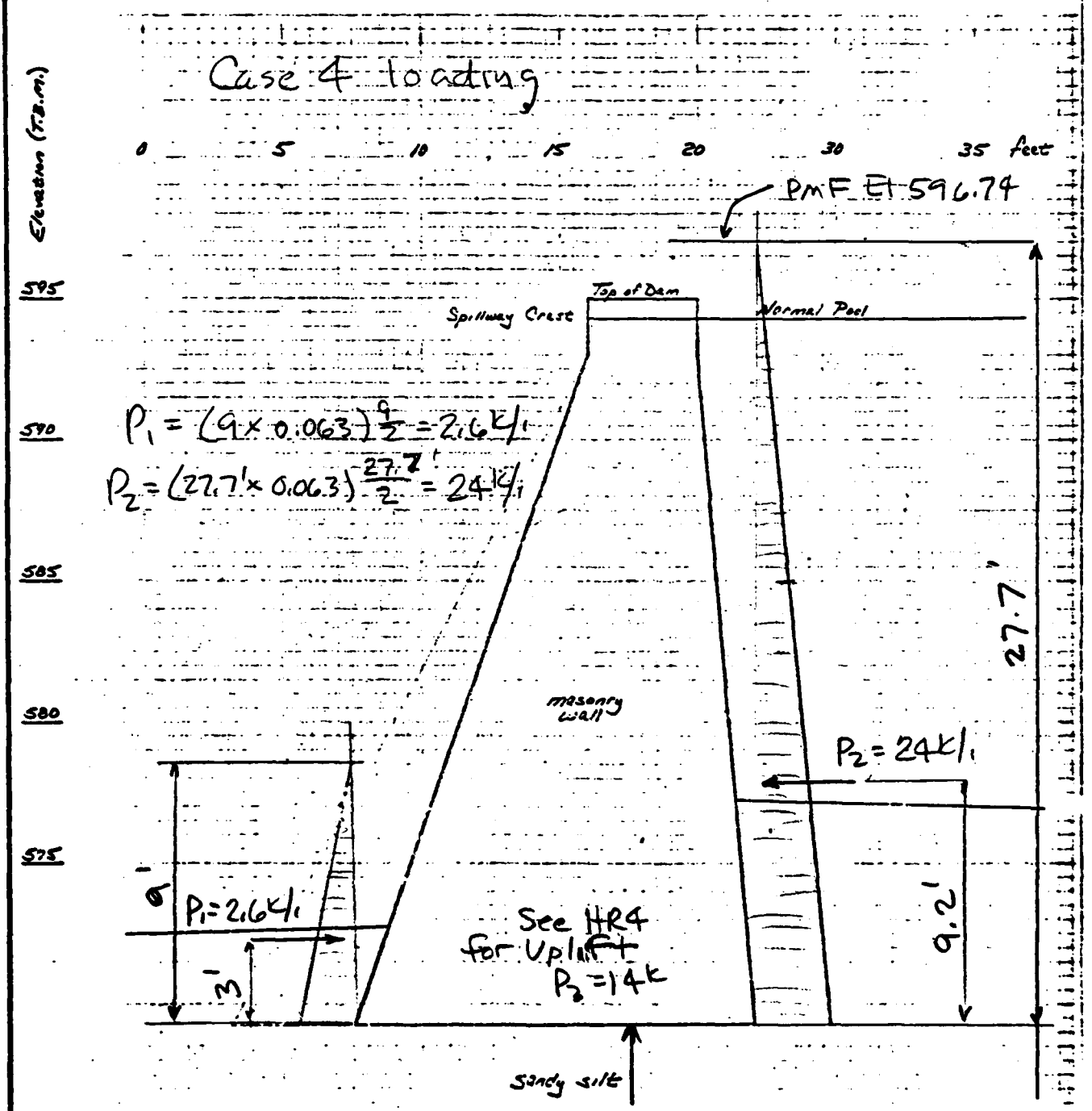
FS against OT = $\frac{304'k}{340'k} = 0.9$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: HILLBURN RESERVOIR DAM — S.O. No. 13866
STABILITY ANALYSIS — Sheet No. 8 of 11
MAXIMUM DAM SECTION AT SPILLWAY — Drawing No. HRS
Computed by DWH | JT — Checked by _____ — Date Feb 1981

Case 4 loading



MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HILLSBURG RESERVOIR DAM S.O. No. 13856
STABILITY ANALYSIS Sheet No. 9 of 11
Ref Drawing No. HR9
Computed by JT Checked by _____ Date Feb 1981

Case 4 - PMF Reservoir El. Full Uplift and 6' tailwater

ΣM_A	W	arm	M	
① to ③	33.1 ↓		299	
Uplift	14.0 ↑		-128	+307
Water Pr.				-349
P_1	2.6k →	3'	8'k	
P_2	24k ←	9.2'	-221'k	
	$\Sigma V = 19.1^k \downarrow$		-42'k	

$\Sigma H = 21.4^k \leftarrow$

$\bar{x} = -42 \div 19.1 = -2.2$

FS against OT = $\frac{307}{349} = 0.88$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HILLBURN RESERVOIR DAM S.O. No. 13563
STABILITY ANALYSIS Sheet No. ' of '
Ref Drawing No. HR10
Computed by JT Checked by _____ Date Feb 1991

Sliding Resistance

$$R_R = V \tan\phi + cA$$

$$= 19.1^k \tan 23^\circ + .19^k/ft^2 \times 15' \times 1$$

$$= 8.02 + 2.9 = 10.92$$

Passive Pressure from Dwnstrm. Wedge (See Sht HR11)

$$P_p = W \tan(\phi + \alpha) + \frac{cA}{\cos\alpha(1 - \tan\phi \tan\alpha)}$$

$$= 130 \times .15^k/ft^3 \tan(23^\circ + 45^\circ) + \frac{.19^k/ft^2 \times 19'}{\cos 45^\circ (1 - \tan 23^\circ \tan 45^\circ)}$$

$$= 48.3^k + 8.82$$

$$= 57^k$$

Total Resistance = 57 + 10.92 = 68k

Factor of Safety against Sliding

Case 1 $\frac{\Sigma \text{Resistance}}{\Sigma H} = \frac{68^k}{18.6} = 3.7$

2 $= \frac{68^k}{23.6} = 2.9$

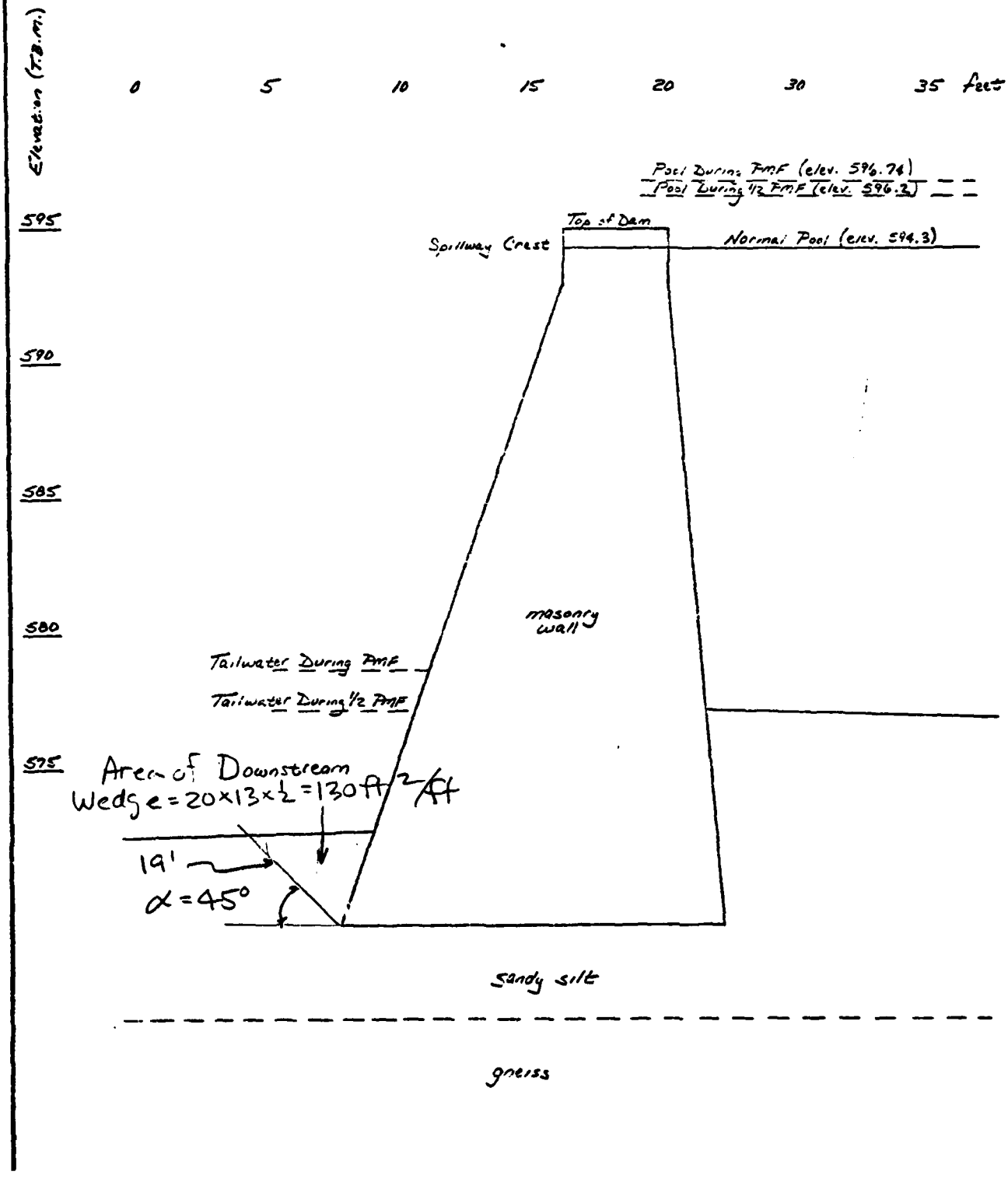
3 $= \frac{68^k}{21.5} = 3.2$

4 $= \frac{68^k}{21.4} = 3.2$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject: HILLSDALE RESERVOIR DAM — S.O. No. 13869
STABILITY ANALYSIS — Sheet No. 11 of 11
MAXIMUM DAM SECTION AT SPILLWAY — Ref Drawing No. HR11
Computed by ZWH / JT — Checked by _____ — Date Feb 1981



APPENDIX E

REFERENCES

REFERENCES

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3. Soil Conservation Service, Soils Inventory and Their Interpretations for Specific Uses (Interim Report), Rockland County, New York, U.S. Dept. of Agriculture, August 1970.

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8. HMR 33, "Seasonal Variations of Probable Maximum Precipitation, East of the 105th Meridian for Areas 10 to 1000 Square Miles and Durations of 6 to 48 Hours," (1956).

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14. U.S. Army, "Inventory of United States Dams," Corps of Engineers, 9 September 1978.

15. U.S. Army, Office of the Chief of Engineers, "Appendix D, Recommended Guidelines for Safety Inspection of Dams," National Program of Inspection of Dams, Volume 1, Corps of Engineers, Washington, D.C., May 1975.

16. George, Thomas S. and Taylor, Robert S., Hydrologic Flood Routing Model For Lower Hudson River Basin, Water Resources Engineers, Inc., 8001 Forbes Place, Suite 312, Springfield, Virginia, January 1977.

17. U.S. Army, Office of the Chief of Engineers, Engineering Circular EC-1110-2-163 (Draft Engineering Manual), "Spillway and Freeboard Requirements for Dams, Appendix C, Hydrometeorological Criteria and Hyetograph Estimates," (August 1975).

18. U.S. Army, Office of the Chief of Engineers, Engineering Circular EC-1110-2-188, "Engineering and Design, National Program of Inspection of Non-Federal Dams," Corps of Engineers, Washington, D.C., 30 December 1977.

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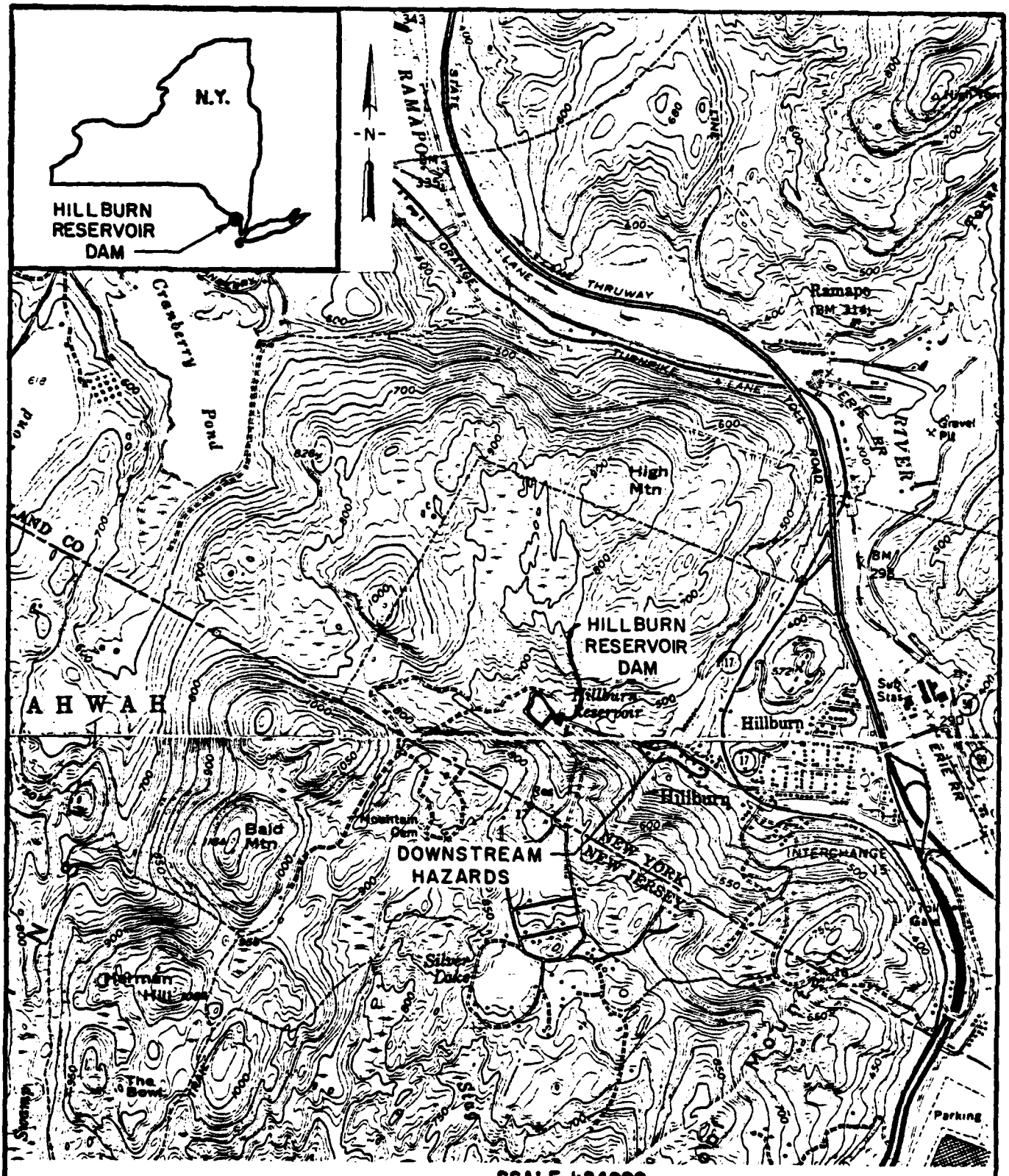
APPENDIX F

DRAWINGS

CONTENTS



SCALE 1:24000

1 1/2 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

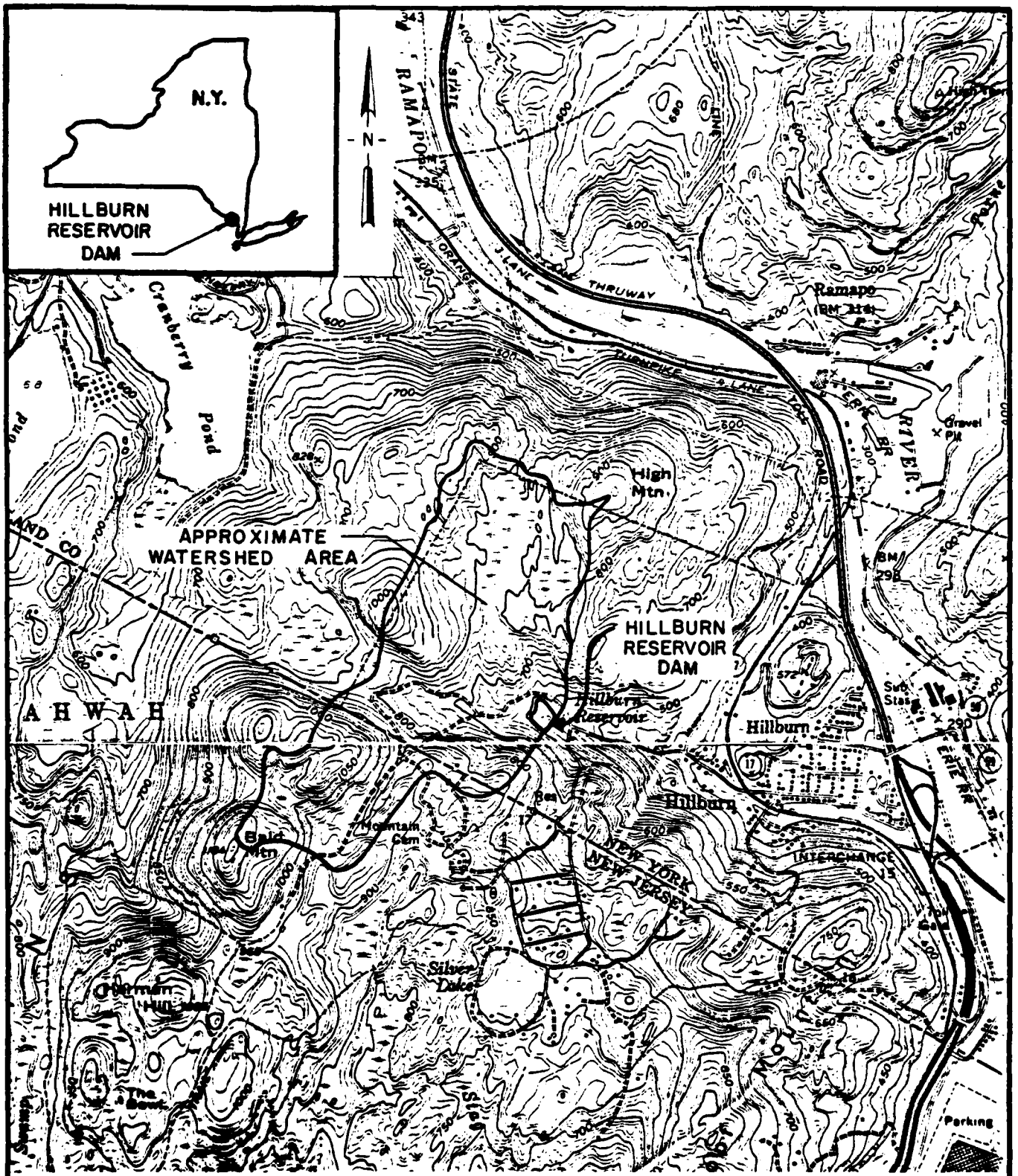
1 0 1 KILOMETER

LOCATION PLAN

HILLBURN RESERVOIR DAM

REFERENCES:

1. U.S.G.S. 7.5' SLOATSBURG, N.Y.-N.J. QUADRANGLE. 1955
2. U.S.G.S. 7.5' RAMSEY, N.J.-N.Y. QUADRANGLE. 1955



WATERSHED MAP

HILLBURN RESERVOIR DAM

REFERENCES:
1. U.S.G.S. 7.5' SLOATSBURG, N.Y.-N.J. QUADRANGLE. 1956
2. U.S.G.S. 7.5' RAMSEY, N.J.-N.Y. QUADRANGLE. 1956

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject HILLBURN RESERVOIR DAM S.O. No. _____
FIELD SKETCH Sheet No. _____ of _____
Drawing No. _____
Computed by _____ Checked by _____ Date _____

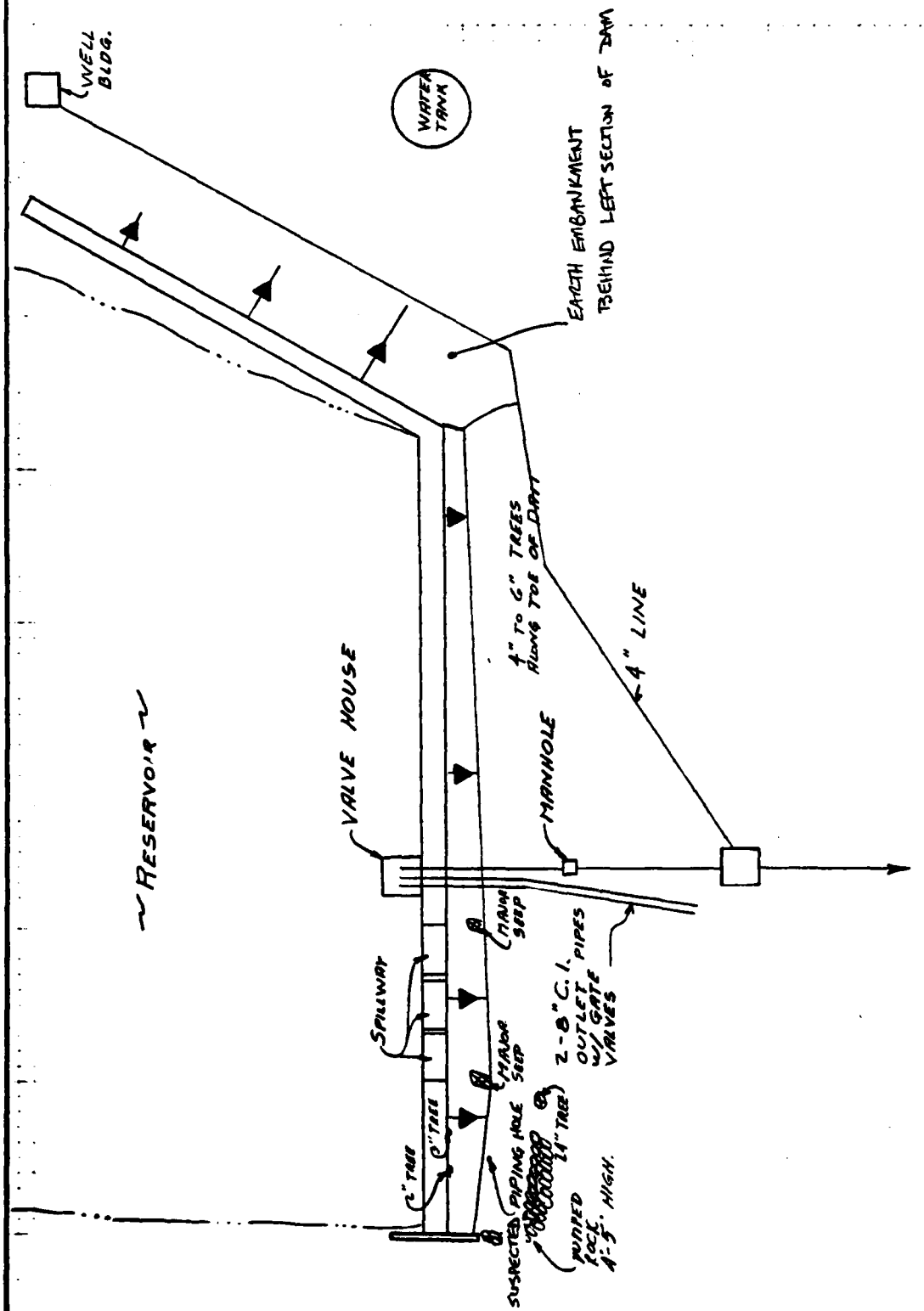
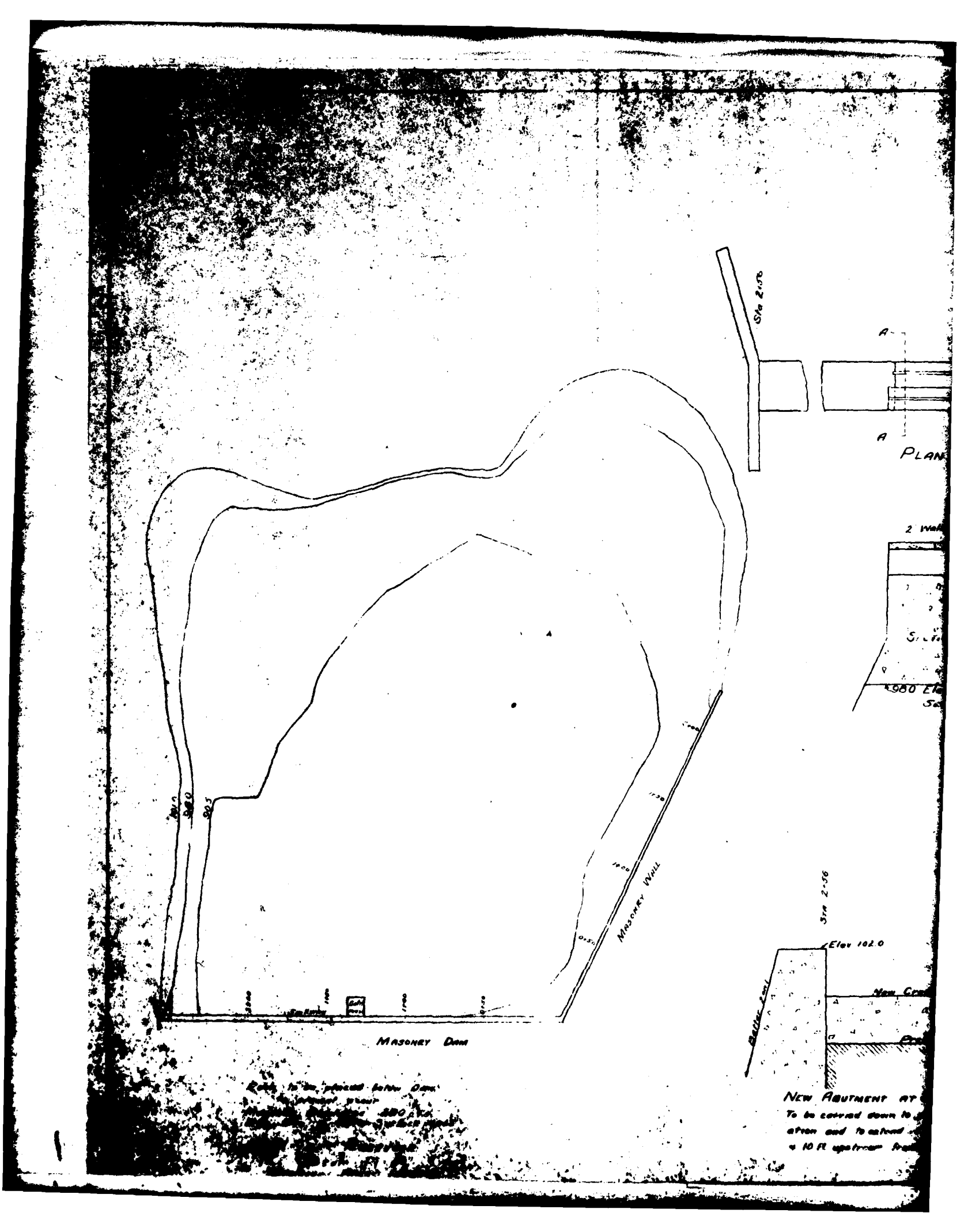
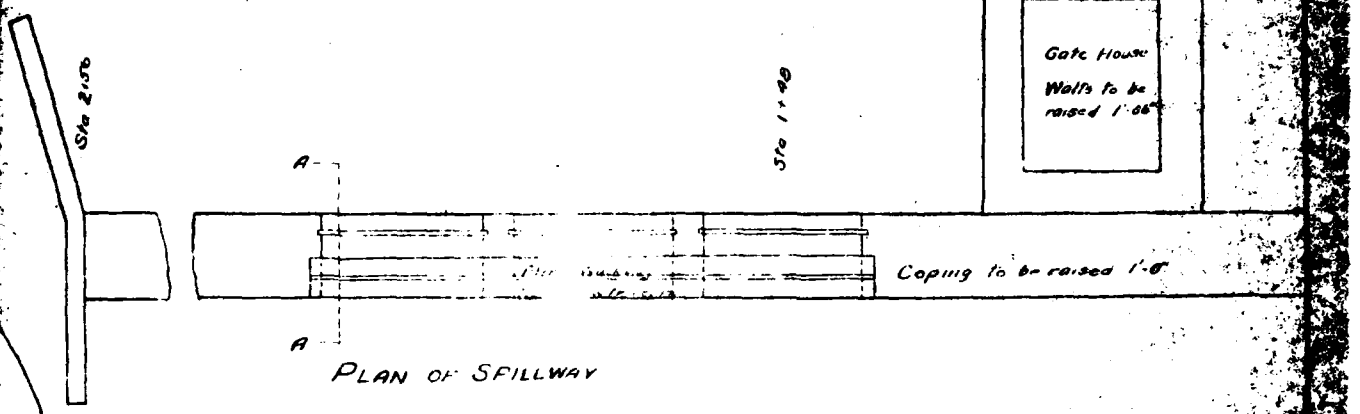
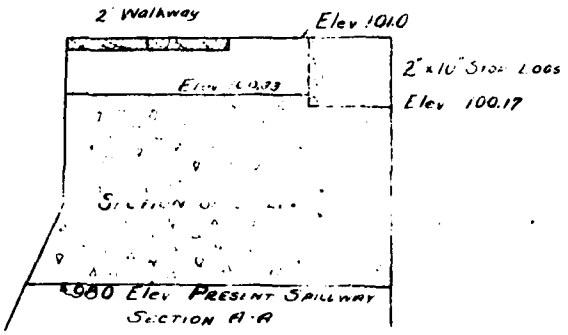


PLATE 1

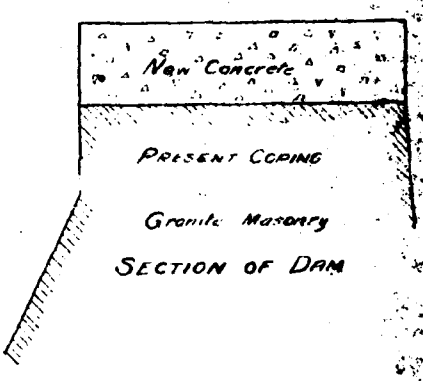

Sta 2+36
A
A
PLAN
2 Wall
980 El
Sta 2+36
Elev 102.0
MASONRY WALL
MASONRY DAM
NEW ABUTMENT AT



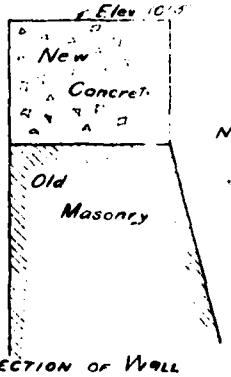
PLAN OF SPILLWAY



SECTION A-A

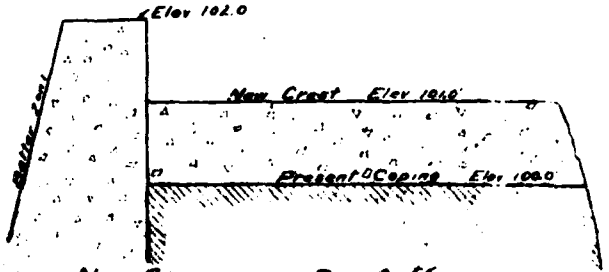


SECTION OF DAM



Note
This section to be built beyond Sta 2+08 to solid ground at El 102.0

SECTION OF WALL



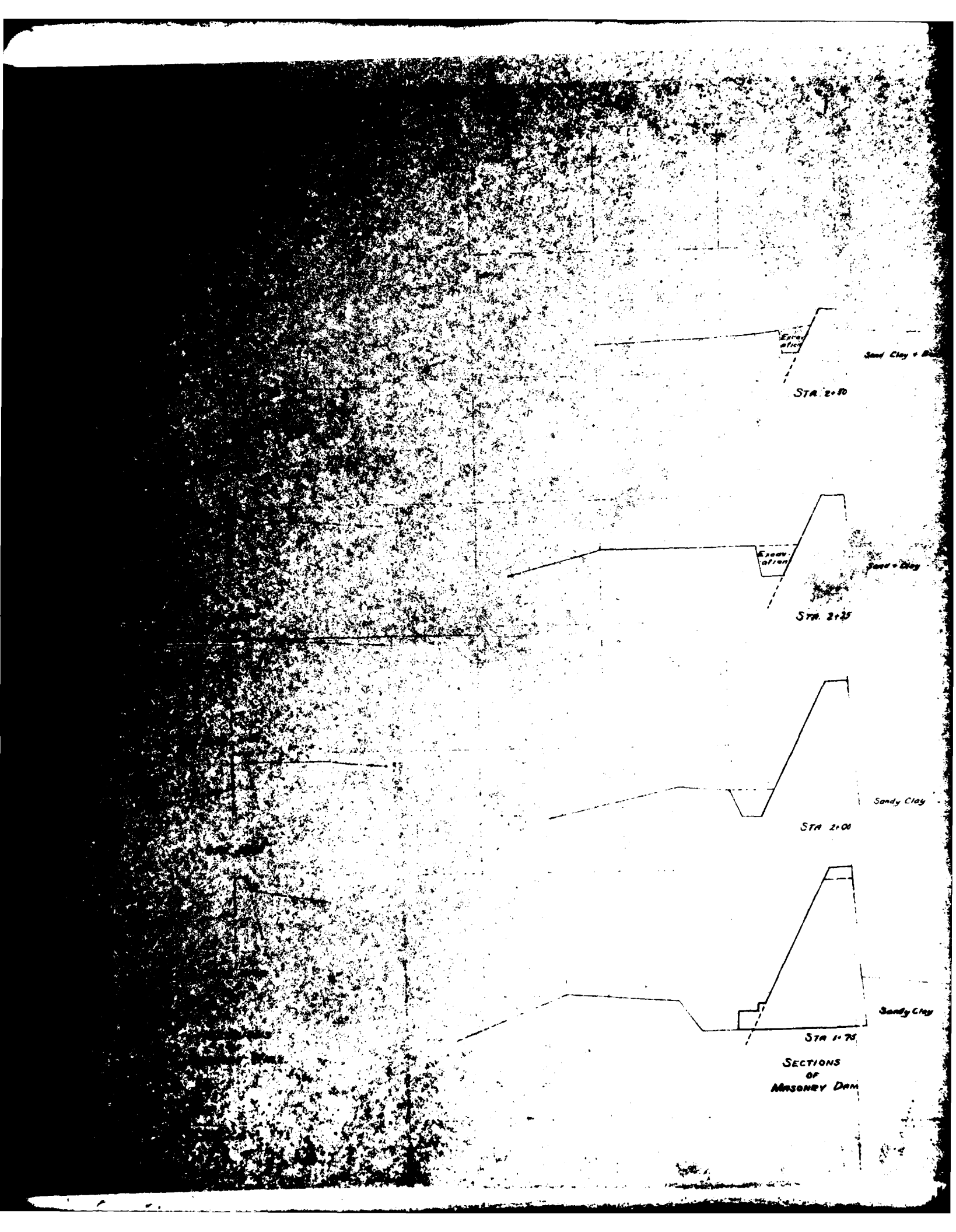
NEW ABUTMENT AT STA 2+56

To be carried down to suitable foundation and to extend 5 ft downstream & 10 ft upstream from edges of crest

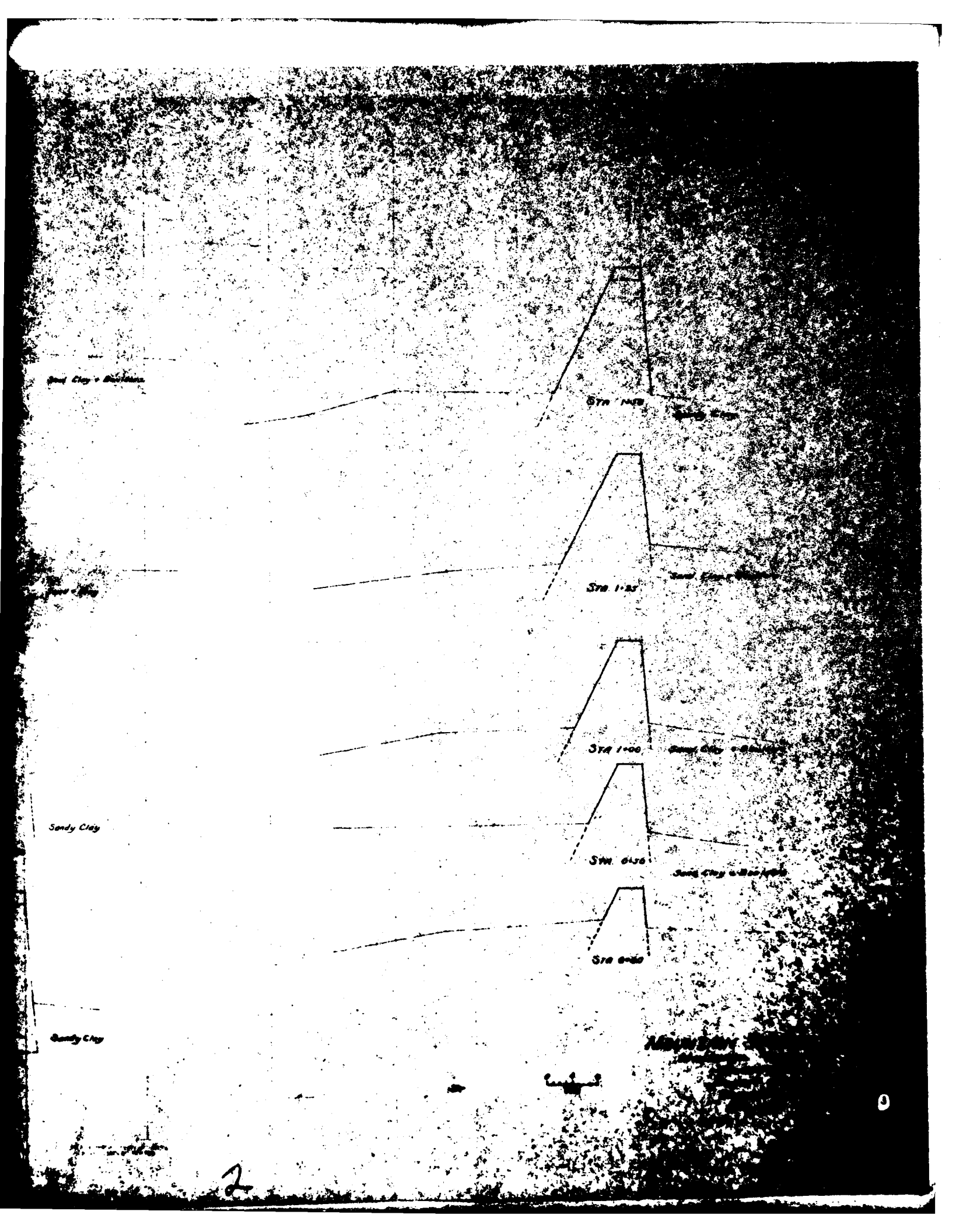
MOUNTAIN SPRING WATER COMPANY
HILLBURN RESEVOIR
Plan
for increasing to 8,500,000 Gallons
by raising Dam and Spillway

Bogert and Pohl
Engineers
New York NY

2



SECTIONS
OF
MASONRY DAM


Sta 1+25
Sta 1+00
Sandy Clay
Sta 0+50
Sandy Clay

AD-A105 765 BAKER (MICHAEL) JR INC BEAVER PA F/G 13/13
NATIONAL DAM SAFETY PROGRAM. HILLBURN RESERVOIR DAM (INVENTORY --ETC(U)
JUN 81 G KESTER DACW51-81-C-0010
UNCLASSIFIED NL

2 OF 2

END
DATE FILMED
11-81
DTIC

APPENDIX G

BACKGROUND DOCUMENTS

(By Visual Inspection)

Hillburn Res. Dam

Dam Number	River Basin	Town	County	Hazard Class	Date & Inspector
196-934	L H.	Ramapo	Rockland	C	4/5 TDA PK

Stream = unknown stream Owner = City of Hillburn

Type of Construction

- ☐ Earth w/Concrete Spillway
- ☐ Earth w/Drop Inlet Pipe
- ☐ Earth w/Stone or Riprap Spillway
- ☐ Concrete
- ☒ Stone w/Concrete spillway
- ☐ Timber
- ☐ Other _____

Use

- ☒ Water Supply
- ☐ Power
- ☐ Recreation - ☐ High Density
- ☐ Fish and Wildlife
- ☐ Farm Pond
- ☐ No Apparent Use-Abandoned
- ☐ Flood Control
- ☐ Other _____

Estimated Impoundment Size 20.5 Acres## Estimated Height of Dam above Streambed 26' Ft.

Condition of Spillway

- ☒ Service satisfactory
- ☐ In need of repair or maintenance
- ☐ Auxiliary satisfactory
- ☐ In need of repair or maintenance

Explain: _____

Condition of Non-Overflow Section

- ☒ Satisfactory
- ☐ In need of repair or maintenance

Explain: _____

Condition of Mechanical Equipment

- ☐ Satisfactory
- ☐ In need of repair or maintenance

Explain: _____

Siltation ☐ High ☐ Low

Explain: _____

Remarks: 2-12" pipes in stream bed with control valves. Small leak top left corner. Gatehouse appears to need minor repairs. Some water might be pumped to storage tank on Property

Evaluation (From Visual Inspection)

- ☐ Repairs req'd. beyond normal maint.
- ☐ No defects observed beyond normal maint.

6-6-29-500 (11E-7-31)

STATE OF NEW YORK

DEPARTMENT OF PUBLIC WORKS

DIVISION OF ENGINEERING

ALBANY

Received Oct 5 1931 Dam No. 196-934

Disposition Copy Oct. 6. 1931 Watershed Delaware

Foundation inspected

Structure inspected

Application for the Construction or Reconstruction of a Dam

Application is hereby made to the Superintendent of Public Works, Albany, N. Y., in compliance with the provisions of Section 948 of the Conservation Law (see last page of this application) for the approval of specifications and detailed drawings, marked Mountain Spring Water Co. Hilburn Restroom

herewith submitted for the { ~~construction~~ / reconstruction } of a dam herein described. All provisions of law will be complied with in the erection of the proposed dam. It is intended to complete the work covered by the application about Dec 1, 1931 (Date)

1. The dam will be on small brook flowing into Ramapo River in the town of Ramapo, County of Rockland and one & one quarter miles from junction with Ramapo River (Give exact distance and direction from a well-known bridge, dam, village main cross-roads or mouth of a stream)

2. Location of dam is shown on the Ramapo quadrangle of the United States Geological Survey.

3. The name of the owner is Mountain Spring Water Co.

4. The address of the owner is Hilburn N.Y.

5. The dam will be used for domestic & water supply

6. Will any part of the dam be built upon or its pond flood any State lands? no.

7. The watershed above the proposed dam is one square miles.

8. The proposed dam will create a pond area at the spillcrest elevation of 2 3/4 acres and will impound 8,000,000 ~~cubic feet~~ gallons of water.

9. The maximum height of the proposed dam above the bed of the stream is 26 feet ____ inches.

10. The lowest part of the natural shore of the pond is over five feet vertically above the spillcrest, and everywhere else the shore will be at least over fifty feet above the spillcrest.

11. State if any damage to life or to any buildings, roads or other property could be caused by any possible failure of the proposed dam Yes

12. The natural material of the bed on which the proposed dam will rest is (clay, sand, gravel, boulders, granite, shale, slate, limestone, etc.) Granite rock and hard pan

13. Facing down stream, what is the nature of material composing the right bank? Granite boulder cut steep gangl

14. Facing down stream, what is the nature of the material composing the left bank? same as right bank

15. State the character of the bed and the banks in respect to the hardness, perviousness, water bearing, effect of exposure to air and to water, uniformity, etc. Said dam has been built for over 25 years with no erosion

16. Are there any porous seams or fissures beneath the foundation of the proposed dam? No

17. WASTES. The spillway of the above proposed dam will be 245 feet long in the clear; the waters will be held at the right end by a abutment steep rocky hillside the top of which will be 1 feet above the spillcrest, and have a top width of 1 feet; and at the left end by a abutment rocky ba the top of which will be 1 feet above the spillcrest, and have a top width of 1 feet.

18. The spillway is designed to safely discharge 305 cubic feet per second.

19. Pipes, sluice gates, etc., for flood discharge will be provided through the dam as follows: 2-12" Castiron pipes & 1-12' cast iron service main.

20. What is the maximum height of flash boards which will be used on this dam? 8 inches

21. APRON. Below the proposed dam there will be an apron built of loose rock feet long across the stream, 250 feet wide and 1 feet thick.

22. Does this dam constitute any part of a public water supply? Yes

SECTION 948 OF THE CONSERVATION LAW

§ 948. **Structures for impounding water; inspection of docks; penalties.** No structure for impounding water and no dock, pier, wharf or other structure used as a landing place on waters shall be erected or reconstructed by any public authority or by any private person or corporation without notice to the superintendent of public works, nor shall any such structure be erected, reconstructed or maintained without complying with such conditions as the superintendent of public works may by order prescribe for safeguarding life or property against danger therefrom. No order made by the superintendent of public works shall be deemed to authorize any invasion of any property rights, public or private, by any person in carrying out the requirements of such order. The superintendent of public works shall have power, whenever in his judgment public safety shall so require, to make and serve an order directing any person, corporation, officer or board, constructing, maintaining or using any structure hereinbefore referred to, remove, repair or reconstruct the same within such reasonable time and in such manner as shall be specified in such order, and it shall be the duty of every such person, corporation, officer or board, to obey, observe and comply with such order and with the conditions prescribed by the superintendent of public works for safeguarding life or property against danger therefrom, and every person, corporation, officer or board failing, omitting or neglecting so to do, or who hereafter erects or reconstructs any such structure hereinbefore referred to without submitting to the superintendent of public works and obtaining his approval of plans and specifications for such structures when required so to do by his order or who hereafter fails to remove, erect or to reconstruct the same in accordance with the plans and specifications so approved shall forfeit to the people of this state a sum not to exceed five hundred dollars to be fixed by the court for each and every offense; every violation of any such order shall be a separate and distinct offense, and, in case of a continuing violation, every day's continuance thereof shall be and be deemed to be a separate and distinct offense. This section shall not apply to a dam where the area draining into the pond formed thereby does not exceed one square mile, unless the dam is more than ten feet in height above the natural bed of the stream at any point or unless the quantity of water which the dam impounds exceeds one million gallons; nor to a dock, pier, wharf or other structure under the jurisdiction of the department of docks, if any, in a city of over one hundred and seventy-five thousand population. This section as hereby amended shall not impair the effect of an order heretofore made by the conservation commission or commissioner under this section prior to the taking effect of chapter four hundred and ninety-nine of the laws of nineteen hundred and twenty-one, nor require the approval by the superintendent of public works of plans and specifications theretofore approved by such commission or commissioner under this section.

The foregoing information and accompanying plans and specifications are correct to the best of my knowledge and belief.

Mountain Spring Water Co., Owner.

By Chas. A. Pohl, Engineer, authorized agent of owner.

Address of signer 39 Cortlandt St. New York N.Y. Date Oct 5 1931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